JULY, 1942

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SECTION OF METAL FINISHING

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When the U. S. decided to make shell cases of steel to conserve brass, a new Zapon finish overcame the problem of preventing corrosion of the inside walls of the cases. Working with the Army from the inception of the project, Zapon perfected a straight phenol formaldehyde coating—S198C—that successfully met all special requirements. No substitutes in this job—too much at stake! Anything less than the best, any skimping might mean failure on the battle field. Corrosion or other effects on the shell case lining must be prevented by the right finish. There must be no compromise with quality specifications on such an important job.

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JULY, 1942

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Finishing Material Containers

Drums, pails, cans and other containers made in whole or in part of steel are exceedingly important to the finishing industry. Without them it would be difficult if not impossible to keep the supply of finishing materials moving steadily from manufacturers to users. It is, therefore, extremely important and necessary that drums, pails, etc. in which finishing materials are shipped be returned for reuse as quickly as possible. The story is a simple and direct one. Ships and guns and tanks are made of steel. So are drums and pails and cans. The less steel needed for shipping containers, the more there is available for direct war supplies. By returning shipping containers to manufacturers of finishing materials, users are doing a great good deed to themselves, their suppliers and our war effort.

When returning empty containers, make certain that they are suitable for reuse. They must be undamaged, clean and complete. Do not allow them to become dented or sprung so that closures do not fit or seams leak. Store them, both full and empty, so that neither inside nor outside becomes rusted or corroded. Clean them thoroughly. This is most easily done at the time when they are emptied. Use thinner to clean out the remnants of finishing material and then use it for thinning the material. Replace all covers, bungs, etc. securely so that each container reaches the manufacturer complete in all its parts.

Return all containers which your finishing material supplier can use now. Clean out your store room of those empty containers. By cooperating you will be assuring yourself of prompt deliveries and your country of your patriotism.

L. H. LANGDON, *Publisher* • T. A. TRUMBOUR, *Business Manager* • DR. WALTER R. MEYER, *Editor*

NEWS FROM WASHINGTON—

To relieve a shortage of steel drums for export shipment on the East and West Coasts, reserve allotments of steel sheets for this purpose were expanded to include both hot and cold rolled sheets by Amendment No. 2 to General Preference Order M-45 issued May 25, 1942.

All grades of butyl alcohol were placed under complete allocation control through issuance of General Preference Order M-159. The allocation started on July 1st. Purchasers will apply for allocations on Form PD-505 and producers and distributors will report on Form PD-506. Deliveries to persons using less than 54 gallons a month may be made without allocation, providing the total of these deliveries does not exceed 2 per cent of a producer's monthly output. Producers also are required to use grain to the fullest possible extent in making butyl alcohol and may not use molasses unless their grain facilities are in use to the utmost. Butyl alcohol is used in the manufacture of explosives, plastics, paint protective coatings and brake fluid.

Isopropyl alcohol was placed on priority by issuance of General Preference Order M-168 issued May 30, 1942. This order places restrictions on the use and delivery of isopropyl alcohol.

Methyl ethyl ketone was placed under priority by issuance of General Preference Order No. M-169 on May 30, 1942. This order restricts the use and delivery of methyl ethyl ketone.

Restrictions on the use of natural resins in the manufacture of playing cards, pencils, house paint label varnishes, toys and farm equipment finishes were removed by an amendment to General Conservation Order M-56, issued June 5, 1942. The original restrictions were necessary because the then visible demand far exceeded supply. This situation is radically changed now, for restrictions placed on manufacture of many products by various other limitation and restriction orders by WPB have so far reduced general demand for natural resins that curtailment of end uses by M-56 is now considered unnecessary. Enough natural resins are now available for such important products as farm equipment finishes and spirit label varnishes. It is considered desirable to allow natural resins to be used in pencil manufacture because a more critical material would be used if resin were not available. The order as amended still prohibits the use of natural resins in barn paints, freight car paints, and road marking paints (except that ½ lb. of Batu gum per gallon may be used in road marking paints). These items are relatively non-essential, use large quantities of natural resins and can be made equally well with cruder materials. The amendment has the practical effect of nullifying M-56 except for the restrictions indicated in the preceding paragraph. The order, as amended, specifically does not put any ceiling on the use of natural resins, because the WPB wishes to encourage the widest use of natural resins as a substitute or extender for shellac and waxes where the more critical synthetic resin would be required otherwise. Our present supply of natural resins in the light of current conditions is estimated to be enough to last three to four years.

The restrictions on the use of bronze powder were lifted by issuance of supplementary Order M-9-c-3 issued June 1, 1942. This permits the use of bronze powder in the manufacture of paste, ink, leaf and paint until December 15, 1942. This order does not permit further manufacture of bronze powder but permits the use of stocks in the hands of those other than manufacturers.

Benzene was placed under complete allocation control by the issuance on June 1, 1942 of an amendment of General Conservation Order M-137. Because of the rapidly growing demand for benzene in making aviation gasoline, synthetic rubber, phenol for plastics and aniline for the high explosive tetryl, it is deemed necessary to prohibit delivery or acceptance of any benzene after July 1, 1942, except by specific authority of the Director of Industry Operations. Quantities of 50 gallons or less to one person in one month are excepted.

The delivery of aromatic petroleum solvents was limited by the issuance of Order M-150 effective May 25. This order was issued with the objective of increasing the production of aviation gasoline and nitration-grade toluol. The order is designed to divert more than half of the two principal aromatic constituents of petroleum solvents—toluol and xylols—from use in the protective coating field to the more important production of aviation gasoline and nitration toluol.

Coatings containing certain organic binders or pigments may not be used for coating steel containers of two gallons or greater capacity after June 20, by the terms of General Conservation Order M-158, announced by the Director of Industry Operations.

This order is expected to save nearly a million pounds a year of critical oils and resins, which are needed for military purposes. Normally, about 1,600,000 pounds each of critical oils and resins are used for drum coating each year.

The order divides coatings into two classes: "Class A," and others. Class A coatings, containing tung, oiticica, perilla or dehydrated castor oils; alkyd, phenolic, vinyl, urea or melamine resin; or cellulose esters or ethers, may not be used for drum coating after June 20 except for export (other than Class A coatings containing tung or oiticica), or orders for the Army, Navy, Coast Guard or Maritime Commission.

The order further provides that after June 20 no person shall apply any coating other than black, except for small areas of color required for marking or legal requirements.

Users of container coatings are forbidden to accept, after June 7, delivery of any Class A coatings, or any colored coating (except black, grey, and white) except for offshore shipment or export, or for the Army, Navy, Coast Guard, or Maritime Commission.

Infra-red reflecting camouflage paint may be manufactured by any company, on a strictly competitive basis, it was announced recently by the Protective Coatings Section, Chemicals Branch, W. P. B., in an attempt to correct a general misunderstanding about the conditions under which this and other protective coatings may be produced.

Infra-red reflecting camouflage paint, specification AXS-684, is one of a group of new and unique coatings designed to meet specialized phases of the war effort. Conflicting reports of its intended uses, its formulation, and limitations on those who may produce and sell it, appear to have obscured the fact that securing contracts is simply a matter of rigid adherence to specification, and the usual competitive bidding procedure normally followed for Government purchase. There is no approved or certified list of suppliers. Many prime contractors are now buying this product from several companies.

Producers of the infra-red paint are cautioned that inspection is most rigid and that specifications must be adhered to closely.

Near Infra-Red and Metal Finishing

By Paul H. Krupp

Fostoria Pressed Steel Corp., Fostoria, Ohio

THERE has been little doubt left in the minds of industrials that "speed" production is necessary for today's Victory Program. In many cases, the only question has been the possibility of reaching the required production schedules.

In many cases where production was stymied on the finishing operations, the near infra-red process has been the solution. This new method offers the answer not only for speed baking and drying of finishes on metal, but also affords quick, easy and low cost equipment installation and is flexible for a variety of peace-time as well as war-time needs.

Since the readers of this publication are undoubtedly most interested in the job which this new process is accomplishing in the paint-on-metal application, the major portion of this story will be told as quickly and fully as possible, to enable each reader to get a clearer picture of how the process operates and description of some of the installations in operation today.

Radiant Energy Not New

In reality, near infra-red is nothing new. Man has been supplied with near infra-red since the world began in the form of radiant energy from the sun. Electrical engineers in their search for new methods to improve products and to decrease production costs, determined that radiant energy as emitted by a filament lamp was possible and practical for industrial use.

Radiant energy travels through the atmosphere in the form of electromagnetic waves. When these waves are directed upon some material substance, they are absorbed quickly and are transformed into usable heat. Utilization of this energy requires no physical conductor nor relatively high ambient temperature to act as a convector.

As is apparent in the attached sketch (Figure 1), only a small part of the electromagnetic spectrum is involved—that part which is nearest to the "light" band and measured in terms of from 7000 to approximately 20,000 Ångström units. Accordingly, the radiant energy as utilized by industry is called "Near Infra-red."

Filament lamps used in the process are called "infra-red" lamps and are designed to generate a minimum of visible or "light" rays—the fewer the better. Filaments may be made either of tungsten or carbon. The accompanying chart, Figure 1, also shows the relative spectral energy distribution curves of both types in the 250 watt size.

Proper Reflectors Important

Before radiant energy emitted by infra-red lamps can be used to advantage for industrial purposes, it must be collected and reflected efficiently. Thus, the first step in utilization is to house the lamps in properly designed reflectors in accordance with "light" reflectance laws. Only by so doing is it possible to exercise proper control of the energy.

The best reflectors are those made of steel plated with gold† because steel stands up best in industrial use and gold is the best reflecting medium for radiant energy. The accompanying chart, Figure 2, shows the results of tests comparing the reflectance of various materials in the visible and near infra-red portion of the spectrum. It is also important to select reflectors that accommodate the variety of lamps used to generate radiant energy and which make it possible to control easily the distribution of this energy.

Determining Use of Infra-red

Although there is nothing mysterious about the near infra-red process or the equipment to operate it, interested industrials who think it can solve their finishing problems should first let experienced engineers conduct tests to verify their thoughts.

Once the desired production and

† This presupposes that the thickness of the gold film is sufficient to prevent complete diffusion under heat.—Ed.

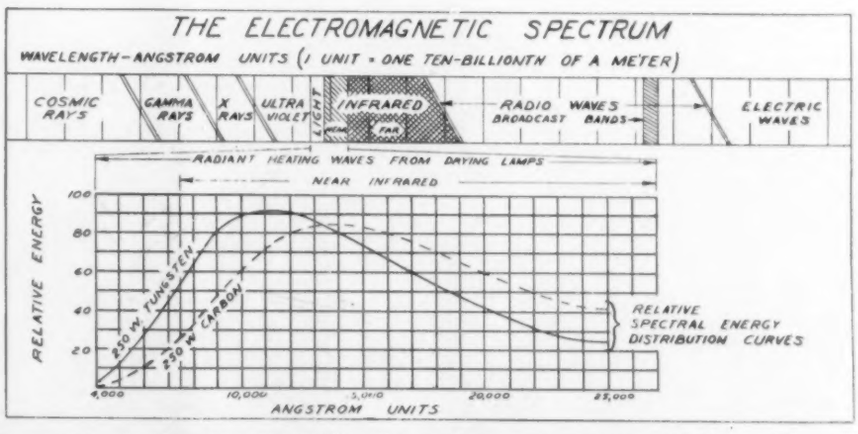


Fig. 1. Drawing illustrating the various energy waves starting with the short cosmic waves and ending with electric waves. The curves illustrate the relative energy radiated by tungsten and carbon filaments at various wave lengths.

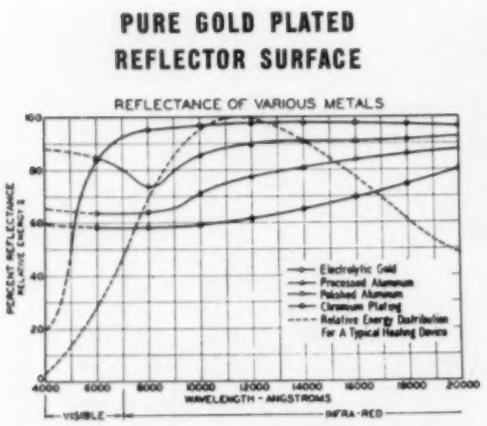
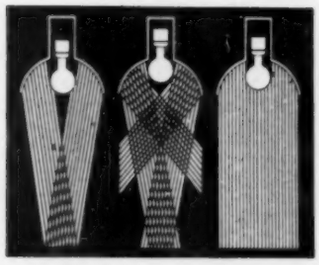


Fig. 2. Chart showing the reflectance values of various materials in the visible and near infra-red portion of the spectrum.



Drawings illustrating various types of reflectors available to control the energy distribution from various types of lamps. The convergent type is shown on the left, a combination convergent and divergent type is in the center, and a parallel reflector is illustrated on the right.

baking time factor per piece has been established as satisfactory—which, naturally, should show quicker and more satisfactory results than conventional methods—it is comparatively easy to figure the overall baking zone length, conveyor speed and other equipment data.

Properly formulated finishes have been important in operating the near infra-red process successfully ever since its industrial application, and today industrial finish manufacturers have available formulas for nearly every finishing problem. Industrials interested in adopting this process should not be satisfied with test results of present finishes used for conventional methods, since it is quite likely a special formula for near infra-red baking will result in a speedier bake and more satisfactory job.

Proper Tunnel Shape

In engineering a near infra-red installation, it is important to design the configuration of the baking zone to the shape and size of the object to be baked. Naturally, the reason is to insure that all surfaces of the object receive radiation so that no one part will be overbaked or underbaked. An excellent example of this is shown in Figure 3. The configuration used in this instance enabled the nose of the bomb to be thoroughly baked without overbaking the tail. These bombs get their finish coats baked in 20 minutes by radiant energy — previously, days were required for air-dry.

Since near infra-red energy travels from the source to the object in the form of waves, highly polished metals reflect some of these radiant energy waves and a longer baking time is required than if the metal were dull. Likewise, white or light color finishes normally should require a longer baking time than black or dark colors because of the reflectance and absorption qualities of these opposites. However, most industrial finish manufacturers have now formulated finishes for use with the process which permit material sprayed with different color paints to travel through the same tunnel, on the same conveyor. In other words, the formulas have been prepared to allow the lighter colors to convert quicker, and in some cases the darker colors have been prepared to consume more time in converting, so that the baking time factor is the same on different colors.

Synthetic Enamels & Infra-red

Synthetic enamels, lacquers and wrinkle finishes all work satisfactorily with radiant energy.

Synthetic enamels are different from the usual enamels in that an oil-modified resin is used in place of a full-bodied oil as the vehicle in the enamel. Since synthetic enamels are designed for baking at relatively high temperatures—from 250° to 350° F.—it is important to know if the pigment contained in the lacquer is of an organic

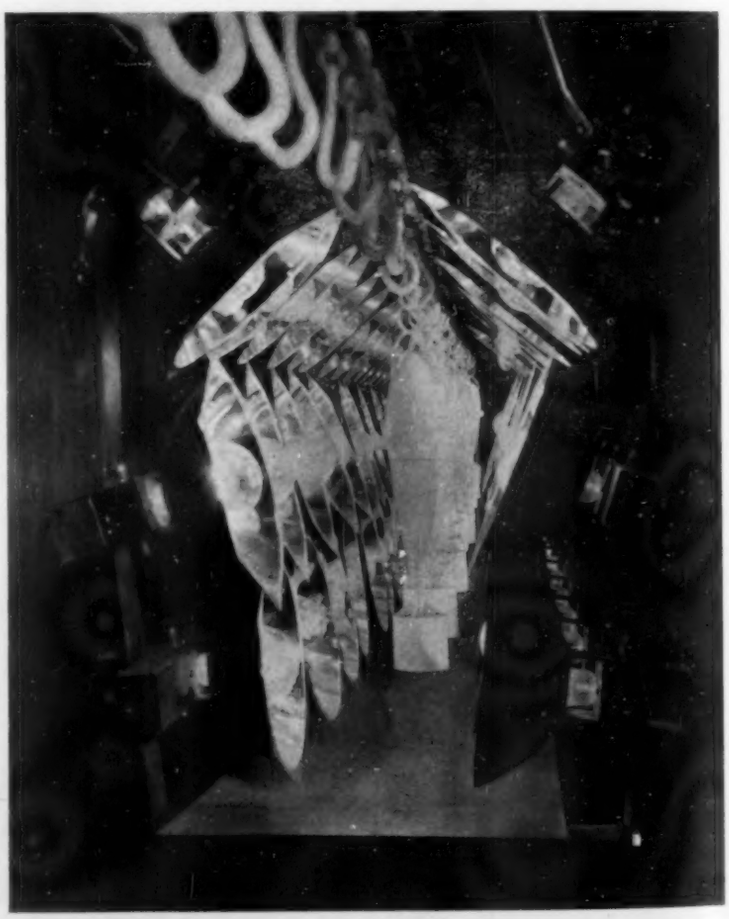


Fig. 3. Illustration of the construction of a radiant energy baking equipment built in configuration to the shape and size of the object to be baked, thus helping to insure uniform over-all baking.

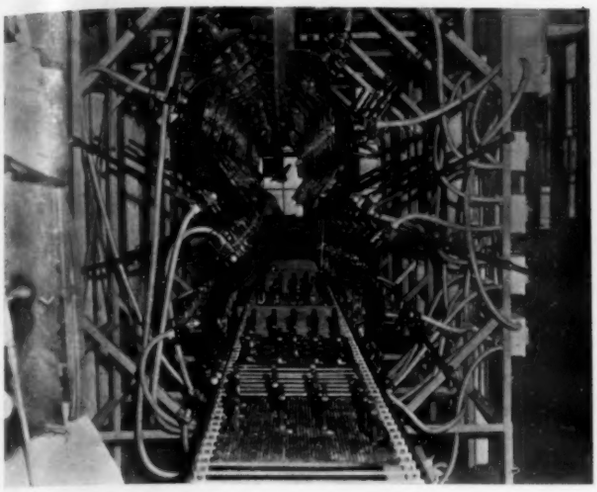


Fig. 4. Duofold arrangement of reflectors to bake material on a moving flat conveyor, as well as to bake material handled by an overhead conveyor.

Fig. 5. A flat type of reflector arrangement giving a very even distribution of energy.

or inorganic type. Experience has proven that organic pigments are more susceptible to charring or discoloration unless baking temperatures are watched carefully and kept within certain boundaries. Substituting inorganic for organic pigments in the formula quickly takes care of this problem.

Perilla, soya, chinawood (tung oil) and linseed oils are all used in the preparation of synthetic enamels. Generally, two or more of these oils are used in varying proportions and the mixture plays an important part in the speed with which the enamel bakes to a hard finish. Experience indicates that the perilla and chinawood varieties are very satisfactory.

Most of the resins used in formulating enamels act favorably with radiant energy—phenolic and alkyd types being especially satisfactory. Thinners, plasticizers and driers act as favorably with the process as with conventional methods.

As a rule, it can be said that synthetic enamels react very favorably with near infra-red. When they do not, a little reformulation on the part of the paint company usually rectifies the trouble very quickly.

Lacquers & Others

The drying of lacquers also is feasible with near infra-red, but care must be taken to avoid temperatures in excess of 200° F., reached in 3 minutes, because of pin-holing and bubbling caused by too rapid evaporation of the solvents, since the conversion or baking of lacquers occurs primarily by a process of evaporation.

Baking japans have not proved adaptable to radiant energy because no advantages of speed or economy are possible. The vegetable oil used in this type of japan is slow to harden and the chief cause for unsatisfactory reaction. Air drying japans having no vegetable oils can be dried with infra-red with little difficulty.

Wrinkle finishes sometimes considered in the synthetic enamel class, are more often grouped separately. These finishes produced by a specially processed enamel, bake at slightly higher temperatures than synthetic enamels, often up to about 450° F. They react very favorably to the near infra-red process—a time factor of 45 minutes with conventional methods usually being reduced to 10 minutes with radiant energy. A wrinkle paint produces that particular effect because it has been formulated to effect a drying of the surface paint film while the under surface is still soft enough to permit the dry skin surface to creep and crawl. If the intensity of radiant energy is too great, the entire film will set up before the creeping and crawling takes place.

It is possible, because of the intense heat obtainable from large wattage lamps or concentrated energy control, to overbake the surface of the paint film before the metal is sufficiently heated to bake the under surface. The solvents are then trapped under the film and cause blistering.

Large, irregularly shaped castings naturally convect the radiant energy applied, to crevices and cooler parts of the casting and thus, a longer time factor is usually necessary.

Flexibility Important Feature

In addition to flexibility for a variety of applications, the process is desirable where only one conveyor and supplementary handling equipment are available. The installation at Keystone Mfg. Co. is a good example of this flexibility. This company estimates that 1000 different pieces for their cameras and projectors are handled by the near infra-red equipment. In Figure 4, it can be seen how part of the reflectors are directed on material moving through the baking zone on a flat conveyor, while others are arranged in tunnel formation to bake the finish on the projector bases handled by the overhead conveyor.

Since this original installation, an "Even Ray" or flat type of reflector giving a very even distribution of energy has been added to part of the baking zone and can be seen in Figure 5. Sixteen hours of production are now completed in 2 hours with an average drying time on the various parts of approximately 15 minutes. Infra-red has entirely replaced the gas oven at this plant, and the process is said to be affording better adhesion and better wrinkle pattern.

The aircraft industry has been using radiant energy extensively in solving "bottleneck" finishing problems. Lockheed and Vultee plants on the West Coast adopted the method early in war production schedules to bake zinc chromate primer on Alclad aluminum

Fig. 6. Reflectors for baking zinc chromate primer on aluminum sheet.

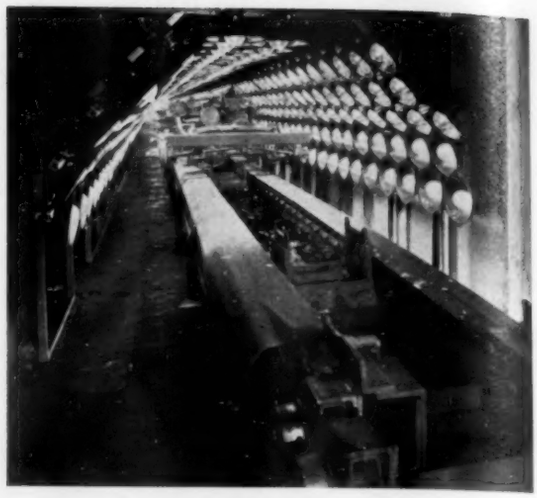


Fig. 7. Tunnel for radiant energy baking of both primer and finished coats on the frame and chassis of jeeps.

sheets of various gauges. Baking time occurs in upwards of 30 seconds, depending on the metal gauge. The quick baking time allows immediate formation of these finished sheets into the parts for fuselage or permits stacking. Figure 6 shows one of these installations at Vultee.

Baking Paint on Jeeps

Willys-Overland found that use of this process enabled them to meet government production schedules on jeeps that would have otherwise been impossible. The tunnel arrangement at Willys, 185 feet long, involves the baking of primer and finish coats of O.D. government specification on the frame and chassis of the jeeps. Figure 7 shows one of the jeeps after it has received its prime coat and just prior to getting its finish spraying.

After the prime coat, applied so heavy it approximates a dip, is sprayed on these scout cars, they start through the section of the tunnel which is lamped with 375 watts for a short distance. This brings the temperature of the metal up very quickly, acting as a special booster. The remaining portion of the tunnel uses 125 watt lamps to the second spraying operation where the finishing coat is applied. The absence of baking equipment at the break in the tunnel where the second spray coat is applied plus the slight cooling off effected by the application, makes it advisable to again boost the temperature up, so 250 watt lamps are used for a short distance and then 125 watt lamps on the final section.

Even though this is a 303 KW job, it can still be considered a wise investment from many angles. Equipment was installed within the old steam convection oven, avoiding disruption of regular line production or change of plant layout. The process affords speed baking and additional assembly almost immediately the material comes from the baking zone. The same tunnel will accommodate standard passenger car material upon termination of war production.

Prevents Lacquer Blushing

Lacquer "blushing" has been prevented since the Welker Mfg. Co. has adopted radiant energy to bake the finish on gas mask strap buckles, and production has increased from one tray of buckles every hour to one tray every 2 minutes. Former methods required an attendant to remove the trays which held the buckles and shake them every 15 minutes to keep them from sticking together. Now the buckles are spread out on heavy manila paper as shown in Figure 8 and completely dry in 2 minutes. This is a tremendous production increase considering the small amount of equipment involved and actual kilowatt load of only 24 KW.

Use of the near infra-red process does not start and stop with industrials where mass production and conveyors are utilized. Figure 9 illustrates how

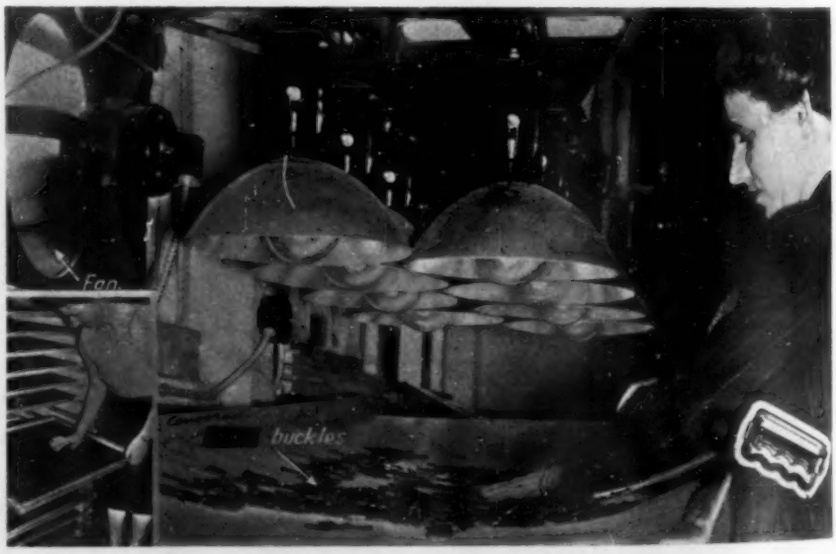


Fig. 8. Baking of lacquer on buckles. This method allows the drying of the buckles in two minutes, which represents a many-fold reduction in drying time, as well as the obtaining of a better finish.

Fig. 9. Workman spraying a military truck preparatory to baking by the near infra-red process.

a workman spray-paints a truck intended for military use preparatory to baking by the near infra-red process. Two banks of reflectors dry the paint in 6 minutes.

Drying & Preheating

Another important way the process fits the metal finishing industry is in connection with the drying of metal parts after they have been cleaned of drawing, machining, rustproofing or other fabricating oils, preparatory to the applying of some type finish. Thorough cleaning of the parts to be finished is essential if an even well-bonded coating of the desired finish is to be attained. Water solutions of the cleaning material best suited for the particular types of foreign matter to be removed are used on practically all work of this type. Where rapid drying of the product must immediately follow the cleaning and rinsing operations, a radiant energy tunnel provides a dependable means of giving quick and complete drying. This not only reduces stand-out time, but brings the metal to a more satisfactory temperature prior to further finishing.

The shortage of various critical metal needed for war production has made it necessary to substitute certain other metals wherever possible. This substitution has opened up new finishing demands and new problems. The near infra-red process has contributed greatly to this finishing activity. Examples of this are substitution of steel for copper, brass and aluminum, and the necessity of finishing the ultimate products with various paints.

Already, the supply of chemicals for paint manufacture has become critical and will undoubtedly become more so for the duration. The critical list will affect the synthetic group most seriously because of the thinners and imported oils used in their preparation.

Even now limitations are in effect on certain finishes, but since many of the industries using the near infra-red process are engaged in war production and demand the speed which the process affords, it will continue to be classified as a necessary tool for the Victory Program.

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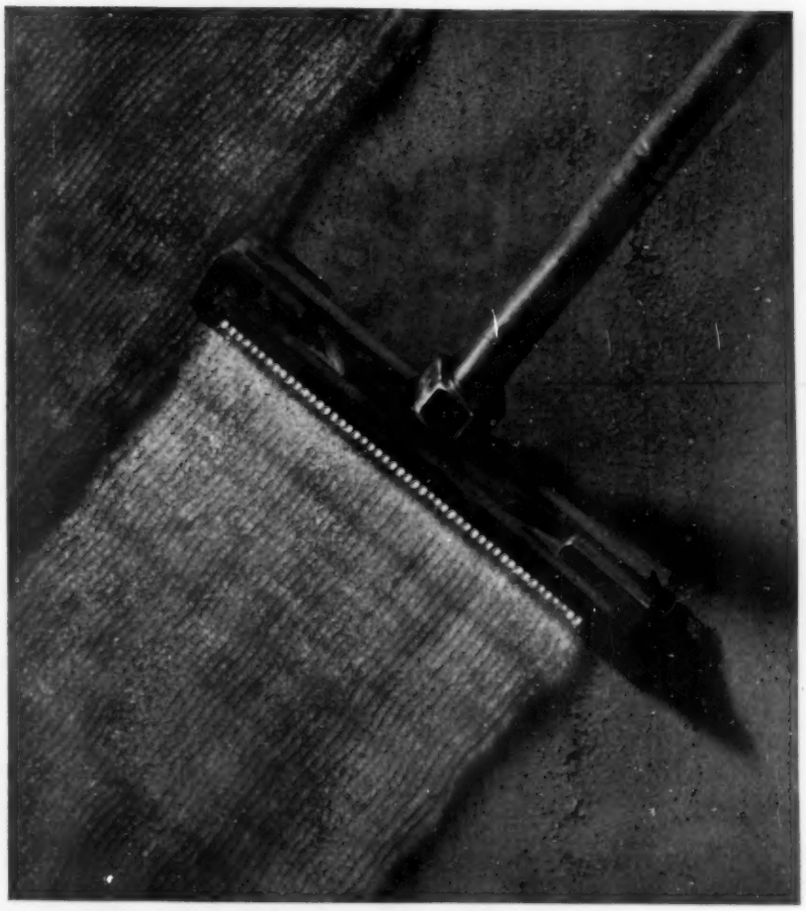
Flame-Priming Steel For Painting †

A RELATIVELY new process for the preparation of steel surfaces for painting, and one that should be of great interest, therefore, to the paint and other related industries, is flame-priming. This is a development of the oxy-acetylene industry. The "tool" used is a blowpipe equipped with a special "head" which provides closely spaced rows of oxy-acetylene flames—"the hottest flame known to man." When these flames are applied to the surface to be treated, adhering rust and scale expand and pop off, leaving the metal underneath relatively unaffected, and warm and dry for the prime coat of paint.

The ease and economy of applying flame-priming, and the resulting high quality of the treated surfaces, are such that the process is being increasingly used on all types of structural steelwork, storage tanks, dams, locks, piling, railroad cars, ships, steelwork on subways, airplane hangars, and pipe lines.

The oxy-acetylene flame-priming process is designed to improve the surface to be painted, as well as the conditions under which the paint is applied. In comparison with painting surfaces cleaned by other processes, such as wire-brushing, pickling, and sand-blasting, flame-priming offers a number of advantages.



Flame-priming is a method for rapidly removing loose rust and scale, leaving the surface warm and dry for the application of paint.

Advantages of the Process

The fact that over 20 million square feet of steel surfaces are flame-primed monthly is in itself indicative of its advantages over previous practices. This procedure not only produces improved corrosion resistance but also increases cleaning and painting rates and reduces setting time for the paint. Moreover painting can be carried out under conditions of low temperature or dampness that would otherwise cause major delays. In addition to removing loose scale and rust, the process drives off moisture from the surface, leaving it warm and dry for the application of paint. This heat not only prevents recondensation, but markedly improves the quality of the priming coat if painted warm. Studies of the action of paint on warm surfaces indicate that the heat, in effect, thins the paint and lowers its surface tension. This imparts a desirable wetting action, causing the vehicle and pigment to penetrate into cracks, crevices, and pitted sections and carrying the inhibitors into contact with the base metal. As a result, a mechanical bond is achieved as well as a technically adhesive one. The improved flowing qualities of paint on warm surfaces results in easier brushing and a smoother finish having fewer voids. An accompanying advantage is that the paint sets up more quickly, and from the metal out. This eliminates the tendency of a skin to form

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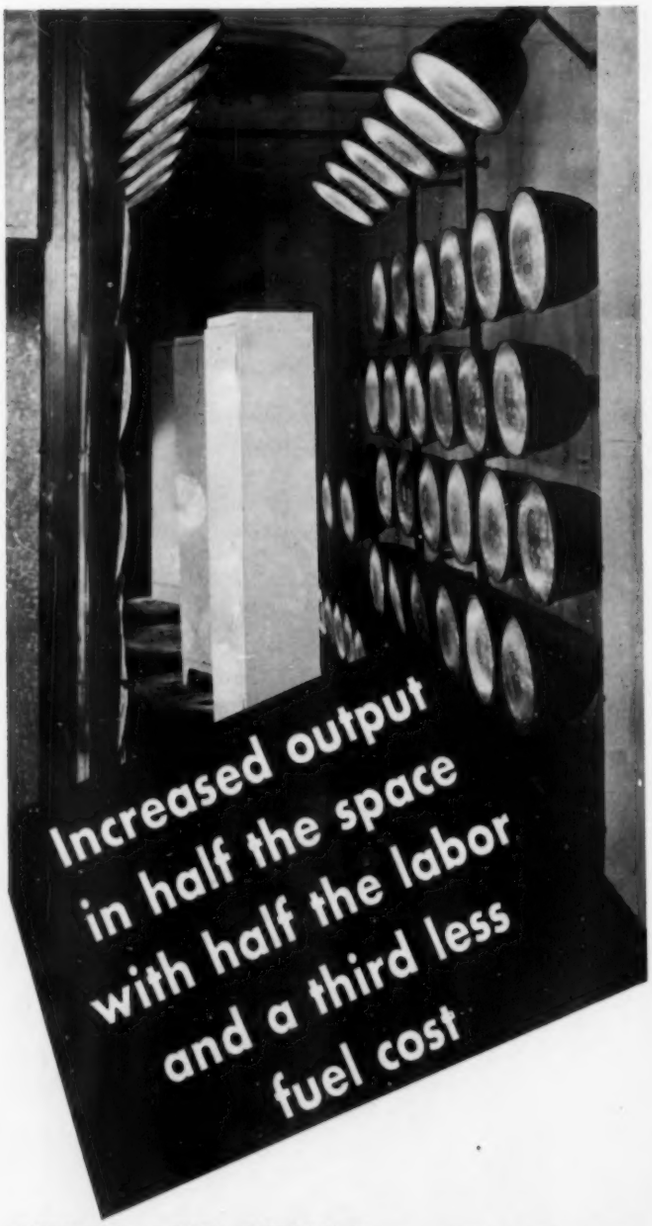

THAT'S THE RESULT of a Gifford-Wood Infra-Red baking and drying installation with NI-R conveyors for handling metal cabinets in a large Philadelphia plant.

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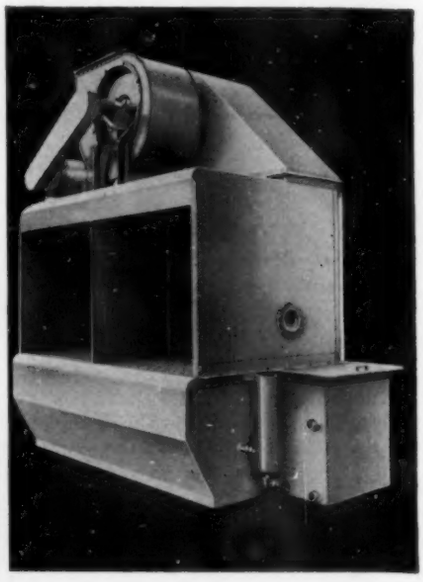

The dangers of processing magnesium are eliminated with the introduction of Hydro-Whirl.

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and blister, as often happens when the surface is painted in the sun.

Scale-Removing Action of the Flames

On all millscale not tightly bonded, the scale-removing action of the flames is quite simple. The intense heat and high velocity of the flames instantaneously raise a superficial layer of the scale to a high temperature. The heating is so rapid that the bottom layers of the scale remain at a relatively low temperature and in a brittle state. The result is obvious: the steep thermal gradient across the thin scale sets up tremendous stresses which, because of the brittleness of the cold underlayer, literally pops the scale away from the base metal. This heating action must of course be rapid, since too slow heating will cause the scale to become ductile and soft, and to fuse to the base metal rather than to spall off under stress. The physically absorbed and chemically combined water is also driven off, and hot, stable oxides are left.

Tightly adherent oxide scale will withstand the action of the flames. However, provided no moisture is present, such scale not only serves to protect the steel from corrosion, but also forms an ideal base upon which to apply the priming coat. In fact, iron oxides are often themselves used as pigments in protective coatings, and since millscale is an iron oxide, it exhibits similar protective properties.

After the surface has been treated, it is then brushed or wiped free of loosened foreign materials; and it is then painted while still warm and dry.

Equipment Required

The heart of the oxy-acetylene equipment required to produce the rigorous heating action is the heating head. One of the accompanying illustrations shows a close-up of such a head in action. The 49 flame ports in this head are spaced 1/8 in. apart, giving a 6-in. flame coverage. The flame ports are No. 75 drill size, or 20 thousandths of an inch in diameter. Despite the extremely small port diameter, the flames are over 1/4 in. long, indicating the high velocity of the burning gases which have a 1-to-1 ratio between oxygen and acetylene.

Depending on the type of work performed, the head is attached either directly to the blowpipe, or to the blowpipe by means of an extension arm. The blowpipe, in turn, is connected by lengths of hose to suitable supplies of oxygen and acetylene.

Flame-Priming Applications

A wide use for the flame-priming process today is on structural steelwork such as is used in bridge constructions.

Large storage tanks are ideal applications for flame-priming. In order to obtain comparative figures, some of the tanks owned by the same company were flame-primed while others were cleaned by sandblasting. Because of the results of the tests, the owner of these tanks has standardized on flame-priming for this and other jobs.

Another outstanding example is the flame-priming, prior to painting, of the Boulder Dam and Grand Coulee Dam drum gates. After the drum gates were prepared for a protective coat by flame-priming, the surfaces were wire-brushed then treated with a rust inhibitor, and finally the prime coat of paint was applied immediately. Results indicated that the heated and dehydrated surfaces helped assure an ideal bond between paint and metal.

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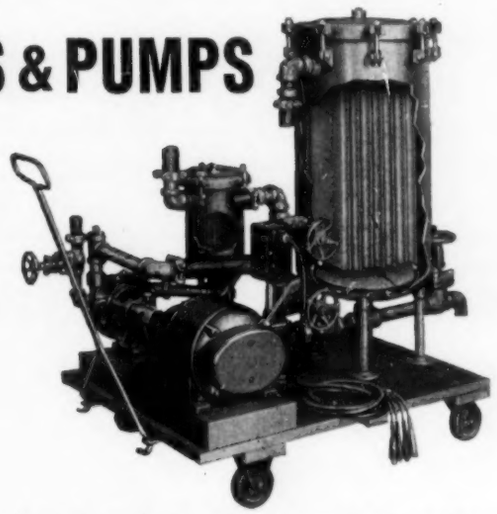

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VOL. 40, NO. 8 METAL FINISHING AUGUST, 1942
PREPARATION, ELECTROPLATING, COATING

Man Hours Lost by Accidents Increase

RECENTLY published statistics show that there has been a great increase in the ratio of man-hours lost due to accidents to total man-hours. This would be expected in view of hiring green help, placing of old help on new jobs and also due to the rush to get out production.

However, time lost is more vital than ever and better instruction and safeguards can markedly reduce accidents in the finishing department.

Grinding, polishing and buffing are potentially dangerous operations and the polishing room foreman should have each new man instructed in the potential dangers, and not let him learn them by experience. These dangers include: wheel breaking due to faulty construction, eccentricity and running at too high speeds; fire due to aluminum and/or magnesium dusts, operation without proper wheel ventilation or lubrication and at too high pressures; eye damage from wheel or metal chips; severe injury from wrong handling of objects with sharp corners, projections; and health hazards of inhaled dust, particularly silicious dust.

In metal cleaning are the hazards of breathing high concentrations of trichlorethylene, skin irritations and dermatoses from caustic alkalies and cresylic acid or phenolic components of emulsion cleaners, and chapping and cracking of the skin from solvents.

The hazards of plating are generally known to the experienced plater but even he may make a mistake. Some hazards are: the high toxicity of cyanide solutions, the danger of hydrogen cyanide formation if acid and cyanide solutions are mixed, the almost equivalent danger of poisoning from hydrogen sulphide if sulphide (oxidizing) solutions and strong acids are mixed, dermatoses from nickel, cadmium and chromium salts, danger of pouring water into concentrated sulphuric acid, explosion from hydrogen in electrocleaning, danger of fire or explosion from mixing sawdust and concentrated nitric acid, the mucous membrane damage from nitric oxide and nitrogen dioxide in bright dipping and chromic acid spray.

In addition there are the ever-present dangers from loose clothing, slipping on wet or bad floors, splashing, falling, etc.

These dangers are not enumerated to frighten anyone intending to work in the plating room. Comparable hazards exist on most other industrial jobs. The important point is that the newcomer be made acquainted with these and other dangers, and be forewarned to prevent trouble. Proper protection involves more than giving the new man goggles, boots and apron. Safety instruction is more vital than ever and the foreman should pay close attention to the flooring, drains, exhausts and equipment in the plating room to insure proper protection to the workman.

With proper equipment, instruction and supervision, plating can be a very pleasant and healthy profession, and no better evidence of this could be desired than the large number of "old timers" in the plating industry who have been working at plating from 20 to 50 or more years.

This Is Washington—

By George W. Grupp

METAL FINISHING's Washington Correspondent

The Future There are some in Washington who believe the future of small metal finishing establishments is very dark if they do not energetically seek out sub-contracts from large manufacturers, become auxiliary units of large manufacturing companies with war contracts, or pool their facilities in small communities.

Air Conditioning and Refrigeration Equipment Delivery of materials needed for emergency repairs to commercial air conditioning and refrigeration equipment has been extended from June 30, 1942 to September 30, 1942 by Amendment No. 1 to Preference Rating Order P-126 issued on June 30, 1942.

Aluminum Survey By the time this issue goes to press the War Production Board expects to have completed a check on about 1,000 foundries using aluminum. This survey is one of WPB's methods of checking up on violations of priority regulations.

Antimony Restrictions Since the supplies of antimony have become relatively more plentiful, control over this commodity has been relaxed by General Preference Order M-112 as amended July 11, 1942. The amended order encourages the substitution of antimony for tin; it limits the use of antimony for automotive batteries for any calendar month to 7 per cent of the total quantity used by the producer during a previous period; the total weight of any metal or alloy shall not contain more than one half of one per cent of antimony, and the use of antimony is barred from use in the preparation, processing or manufacturing of "white pigments, opacifiers or frits for non-acid-resisting ceramic enamels," or for "white inorganic pigments for non-ceramic enamels, paints, lacquers or printing inks, except as a reinforcement or chemical agent not to exceed 2% by weight of pure pigment contained."

Arsenic The filing of Form PD-490 is no longer necessary for a person seeking five hundred pounds or less of arsenic, according to July 11, 1942 Amendment No. 1 to Arsenic General Preference Order M-152, provided such person filed with his supplier at the time of ordering a certificate that stipulates that if the delivery is made he will not receive in excess of five hundred pounds of arsenic during the current calendar quarter. Producers and distributors must list on Form PD-490 and PD-491 the amount they propose to deliver to each purchaser of less than 500 pounds of arsenic during the forthcoming calendar quarter.

Bauxite Allocation Control The War Production Board foresees increased production of bauxite and alumina by placing under complete allocation control all such natural resources located in Arkansas, Alabama, Georgia, Virginia, Tennessee, Mississippi and other states, therefore on July 7, 1942 it issued Aluminum General Preference Order M-1-h which provides that consumers of bauxite must file their requests for allocation on Form PD-567. Alumina users must use Form PD-568.

Bicycle Restrictions Following the issuance of July 17, 1942 Amendment No. 1 to Limitation Order L-52, which provides that "from July 1, 1942 to August 31, 1942, inclusive, no bicycle manufacturer shall manufacture more bicycles than two times 32% of the average monthly number of bicycles produced by him in the calendar year 1941", the Office of Price Administration announced a 25 per cent reduction in the already allotted quota of bicycles for rationing in July. The August quota was withdrawn entirely until a new allotment is agreed upon.

Birth Certificate Requirement Lifted War Manpower Commission Chairman Paul V. McNutt has lifted the requirement of birth certificates of native Americans who wish to be gainfully employed in secret war production industries if they were born in states and in localities where such records were not kept until recent years.

Black Copper Production At a recent meeting of the Brass and Bronze Ingot Makers Industry Advisory Committee of the WPB, the opinion was expressed that the production of "black copper with copper content of 86 per cent in the reverberatory type furnaces by most ingot makers places heavy burdens on the ingot maker's equipment." It was their opinion that the production of 80 per cent black copper would not present such production problems.

Brass & Copper Civilian Products The restrictions on the use of brass and copper in certain civilian products as ordered by Conservation Order M-9-c have been revised in Amendment No. 2 which provides that the original Order does control shoe findings and footwear covered by Conservation Order No. M-9-c-1, fire protection equipment covered by General Limitation Order L-39, motorized fire apparatus covered by General Limitation Order L-43, Jewelry covered by Supplementary Conservation Order M-9-c-2, musical instruments covered by Supplementary Order L-37-a, and bronze parts, bronze ink, bronze leaf and products made with bronze paste, bronze ink, bronze lead and bronze powder (other than decalcomania and ship bottom paint) covered by Supplementary Conservation Order M-9-c-3. The provisions of this amendment do not apply to finished brassiere hooks, slide fasteners, garter trimmings, hose supporters, snap fasteners and grippers, hook and eyes, corset clasps, eyelets, loops, mattress buttons, staples, slide and trouser trimmings, pin fasteners, pins and buckles; but it does apply to the manufacturing, processing, assembling, and finishing of these items. The amendment lifts the ban on the use of brass and copper in the manufacture of radio vacuum tubes, special types of radio apparatus, and chimes and bells under certain conditions.

Brass Foundry Needs Considered The Copper Branch of the WPB will seriously consider the authorization of copper for brass and bronze foundries for orders bearing ratings lower than A-1-k provided they are orders originating with railroad, street-car, bus, public utility, mining, petroleum and water works companies, or with hospitals, schools, fire

departments, war production textile industries, and defense housing, or with companies who need such materials to repair industrial machinery, farm equipment, elevators, road building equipment, food preservation machinery and dairy equipment. The Copper Branch is asking foundries to use a lower grade of copper in the making of many kinds of castings because electrolytic copper and No. 1 copper scrap are needed for ammunition.

Brass Foundry Reports Brass and bronze foundries, beginning August 1st, 1942, must report each month on Forms PD-123A and PD-123B their deliveries to customers during the previous month. It is only upon filing such reports and upon the making of application on revised Form PD-59 that material will be allocated to them. In addition to that, all foundries must keep a record on how their materials and products have been used. Each customer must be given the appropriate allocation classification symbol and purchasers' symbol for the purpose of showing the end-use of all materials and products deliveried on each order.

Bucy and Martin E. H. Bucy who was head of the Paint, Varnish, Lacquer and Printing Inks Unit of the WPB has been appointed Chief of the Protective Coatings Section of the Chemicals Branch. Before coming to the WPB Mr. Bucy was technical director in charge of research and development of the Zapon Division of the Atlas Power Company. Wells Martin, formerly president of the Martin Varnish Company of Chicago, Ill. will be assistant chief of the Section.

Chemical Solvent Reclaiming Campaign The Industrial Salvage Section of the WPB Bureau of Industrial Conservation has started an educational campaign under S. Donald Perlman for the reclaiming and recovering of millions of gallons of chemical solvents and oils which are now being discarded. "There is an economy side to the picture of reclaiming solvents as well as the presently vital factor of conserving them for war production," Mr. Perlman said. "A solvent that costs 20 cents a gallon may often be reclaimed for as little as 2 cents a gallon", Perlman added.

Chromium Congress appropriated $75,000 to the Bureau of Mines of the Department of Interior to enable it to seek commercially practical ways of recovering chromium from the low grade chromite ores in the Western states.

Coal & Coke Inventories Permitted According to Amendment No. 2 of Preference Rating Order P-89, chemical producers are permitted to build up inventories of coal and coke for this forthcoming winter.

Cobalt Order Extended The Cobalt General Preference Order M-39 as amended on February 7, 1942 and which was to expire on the first of July has been extended indefinitely by the War Production Board.

Copper Price Reductions Price Administrator Leon Henderson on July 17, 1942 reduced the maximum prices on thirteen classes of copper alloy scrap in Amendment No. 1 of Revised Price Schedule No. 20. The amendment has reduced bell metal from 15.75 cents a pound to 15.50 cents, high grade bronze gears from 13.50 cents a pound to 13.25 cents, babbitt-lined brass bushings from 13.25 cents a pound to 13.00 cents, red trolley wheels from 11.00 cents a pound to 10.75 cents, aluminum bronze (Ford) gears from 9.25 cents a pound to 9.00 cents, soft red brass (No. 1 Composition) from 9.25 cents a pound to 9.00 cents, soft red brass borings (No. 1 Composition borings) from 9.00 cents a pound to 8.75 cents, red brass breakage (irony composition) from 7.75 cents a pound to 7.50 cents, yellow brass castings from 6.75 cents a pound to 6.25 cents, automobile radiators from 7.50 cents a pound to 7.00 cents, Formula C (High-grade Bronze and High-grade Bronze Borings) was reduced about 0.75 cents a pound, Formula D (High Lead Bronze and High Lead Bronze Borings) was reduced about 0.75 cents a pound; and Formula E (Refinery Brass) was reduced about 1.25 cents per copper unit.

Copper Recovery Program Ernest A. Tupper, Chief of the Inventory and Requisition Branch of WPB revealed on July 16th that during the first fifteen days of the Government copper recovery program one million pounds of idle, excess and frozen inventories of copper and copper alloy products were directed into war production. In spite of this success Mr. Tupper warned that "although a good start has been made the acquisition of idle and excess inventories of copper and copper alloys will have to be stepped up five fold, both by voluntary sales and Government purchase and resale in order to keep war production assembly lines operating at full capacity."

Copper Uses Extended The WPB Director-General of Operations issued on July 10, 1942 Amendment No. 3 of Copper Conservation Order M-9-c as amended May 7, 1942 which permits manufacturers to use copper products or copper base alloy products in the "manufacturing, processing, assembling or finishing of any item or article on the Military Exemption List".

Cutlery Interpretation Interpretation No. 1 on Cutlery General Limitation Order L-140 states that "nothing in this Order shall limit the production of sterling silver flatware". Carving knives, forks and steels are not considered silver flatware even though they have sterling silver handles.

Fire Protection Equipment Fire protection equipment General Limitation Order No. L-39, as amended July 11, 1942 provides that the use of copper or copper base alloys is banned on all extinguisher pumps, except tetrachloride extinguishers. The restrictions on brass couplings and foam extinguishers of the original order are still in effect.

Fishing Baits, Flies and Lures General Limitation Order L-92, according to Interpretation No. 1 issued on July 17, 1942, does not prohibit the manufacture of baits, flies and lures if no critical materials are used. Fish hooks may be converted into lures, flies and baits if no critical materials are added. The production of new fish hooks, the interpretation points out, is limited to 12.5 per cent of the number produced in 1941.

Graphite Crucibles Madagascar flake graphite Conservation Order M-61 as amended on July 7, 1942 permits jobbers to acquire crucibles made of this material without making application to do so. However, the WPB retains control because no jobber can make deliveries without specific authorization. Beginning August 1st applicants for crucibles containing Madagascar flake graphite must use Form PD-575 instead of Form PD-1A.

Importers Price Ceilings The Office of Price Administration has granted permission to importers to sell to industrial and commercial users, under certain conditions, imported commodities at prices above the March, 1942 price ceilings established by the General Maximum Price Regulation.

Inventories Released Priorities Regulation No. 13 issued on July 7, 1942, which affects thousands of business concerns, has freed hundreds of thousands of tons of frozen idle inventories of

about two hundred different kinds of metals, chemicals, and miscellaneous critical materials including aluminum, antimony, babbitt, beryllium, brass, brass mill scrap, bronze, cadmium, chromium, cobalt, copper, Inconel, iridium, lead, magnesium, rhodium, solder, terneplate and scrap, tin and tinplate, tungsten, zinc, zinc scrap, butyl alcohol, methyl alcohol, benzene, nickel solutions and nickel salts, oiticica oil, resins, etc.

Labor Freezing Possible A recent statement by Chairman Paul V. McNutt of the War Manpower Commission revealed the pressure the Government may exercise if management and labor fail to cooperate with the Administration's efforts to solve employment shortages, maladjustments, and the piratings of skilled war workers from one war industry to another. If these problems cannot be solved by voluntary methods, then the WPB, the Army and Navy and the Selective Service will aid the Commission in freezing all skilled workers to essential jobs for the duration of the war.

Lead Pool Instead of establishing a lead pool by a separate order each month, the WPB with Supplementary Order No. M-38-j of July 4, 1942 ruled that "each refiner shall set aside from his production of lead during each calendar month beginning with the month of July, 1942, a quantity equal to 15% of the total quantity of lead produced by such refiner during the month of May, 1942."

Lead Prices Amendment No. 3 to Revised Price Schedule No. 70 on lead issued on July 11, 1942 permits sellers to charge buyers for the copper contained in lead covered copper cables, and in terminals of submarine batteries. The maximum prices permitted are governed by Revised Copper Scrap and Copper Alloy Scrap Price Schedule No. 20 as Amended.

Liquidation Sales Supplementary Order No. 10 issued on July 15, 1942 by OPA and effective July 20, 1942 stipulates that practically all liquidation sales made by judicial agents of bankrupt firms are exempt from the maximum price regulation. "This exemption will free the courts of a heavy administrative burden without resulting in upward pressure on other prices," Price Administrator Leon Henderson said.

Machinery & Machine Parts Prices The Office of Price Administration issued an amendment to Maximum Price Regulation No. 136, effective July 22, 1942, which freezes the prices of chemical processing machinery, die casting machinery, foundry machinery, paint-making machinery, plastics, welding and fabricating machinery, rod and wire working machinery, rolling mill machinery, soot blowers and cleansers, oil, gas and steam engines, core drilling machinery, all sorts of electrical equipment, signal equipment, air conditioning equipment, metal marking and numbering machines, mechanical measuring instruments, abrasive wheels, and other machinery and machine parts as of October 1, 1941.

Metal Drum Exports Because of the increasing shortage of metal drums and containers and gas cylinders the Office of Exports, Board of Economic Warfare has banned the use of such drums and containers for goods in excess of 10 gallons in the exportation of such materials beginning July 15, 1942 except by individual export license. However, such drums and containers, either filled or empty, may be shipped to Canada, Great Britain, Northern Ireland, Newfoundland, Greenland, Iceland and U.S.S.R. under a general license.

Metal Shelving Restrictions The manufacturing of metal shelving has been banned, except by authority of the Director of Industry Operations, as provided in Amendment No. 3 to Supplementary Metal Office Furniture and Equipment Limitation Order No. 1-13a issued on July 1, 1942.

More on Metal Shelving According to Amendment No. 4 to Supplementary Limitation Order L-13-a issued on July 15, 1942 the restrictions of the original order do not apply to "specific orders, contracts and subcontracts for metal shelving or metal lockers" for the Army, Navy and Maritime Commission.

Metal Signs On July 15, 1942 Amendment No. 2 to General Limitation Order L-29 was issued to permit manufacturers of metal signs to dispose of certain of their inventories frozen by Priorities Regulation No. 13 issued on July 7, 1942. The amendment rescinds the L-29 provision which required metal sign manufacturers to file with WPB by July 15th a complete record of all their raw and semi-processed metal inventories.

Mercury Prices In Amendment No. 1 to Revised Price Schedule No. 93 issued July 7, 1942, and effective immediately, the maximum base price on mercury produced in Arizona, California, Idaho, Nevada, Oregon, Utah and Washington is fixed at $191.00 per 76 pound flask f.o.b.; mercury produced in Arkansas and Texas the maximum base price is fixed at $193.00 per 76 pound flask f.o.b.; mercury imported from Mexico the base price is $193.00 per 76 pound flask f.o.b.; and mercury produced outside of continental United States and Mexico may enter the United States Pacific Coast ports at $191.00 per 76 pound flask f.o.b.

Nickel Scrap Nickel scrap Order M-6-c was amended to conform with the alloy steel segregation Order M-24-c. This amendment covers scrap containing one or more per cent of nickel but it does not include nickel scrap whose principal part is aluminum or 40 per cent of copper since these forms of scrap are covered by Orders M-1-d and M-9-d respectively. This amendment provides that ferrous nickel must be segregated. The original order limiting the monthly melting of scrap to 300 pounds of nickel content has been removed; but no one is allowed to melt nickel scrap without specific authority from the WPB Director of Industry Operations. Under this amendment any melter, without regard to primary nickel allocated to him in conformity with the original order, is permitted to receive nickel scrap under certain conditions.

Non-Ferrous PRP Applications According to Preference Rating Order P-73 as amended July 14, 1942, smelters and refiners of antimony, cobalt, copper, iridium, lead, mercury, molybdenum, nickel, platinum, tin, tungsten, and zinc who are operating under Order P-73 will not have to file PRP applications for the third quarter of 1942. Pending the completion of a uniform system of priority ratings for maintenance and repairs needs P-73 will apply to all non-ferrous smelters and refiners.

Dewey L. Pierce Dewey L. Pierce of Riverside, Conn. who was Executive Vice President and Director of the C. A. Woolsey Paint & Color Company and of the New Jersey Paint Company, has been appointed Commodity Procurement Advisor on Paint, Varnish, Lacquer and Waxes of the WPB.

Portable Lamps and Shades Portable lamp and lamp shade manufacturers have been given permission by Amendment No. 3 to General Limitation Order L-35 issued July 13, 1942 to use their existing supplies of fabricated or semi-fabricated metal, metal parts and lamp cords as of March 23, 1942. Lamp cords, in addition to this Order, are also subject to Copper Conservation Order M-9-c of May 7, 1942.

Steel Drum Deposits In the shipping of carbon tetrachloride shippers may charge a reasonable deposit on steel drums according to Amendment No. 2 of Revised Price Schedule No. 79-1 issued on July 2, 1942.

Electrodeposition of the Metals of the Platinum Group†

BY DR. K. SCHUMPELT

Baker & Co., Inc., Newark, N. J.

Of the six platinum metals, rhodium only is at present being electroplated on an extensive commercial scale. However, further research on suitable plating baths for the other five metals, notably for platinum and palladium, which are far more abundant than rhodium, will undoubtedly lead to eventual adoption of these metals by the plating industry. Details as to the rhodium bath composition and operation are presented, together with formulas for platinum and palladium plating baths suitable for flash coats. An undercoat of nickel is recommended for most cases.

Introduction

The group of platinum metals comprises the following six:

	Atomic Weight	*Sp. Gr.*
Platinum	195.2	21.4
Iridium	193.1	22.4
Osmium	190.9	22.5
Palladium	106.7	12.16
Rhodium	102.9	12.4
Ruthenium	101.7	12.1

Of these six metals only platinum, palladium and rhodium have found practical applications in the field of electroplating. Prior to 1915, also particularly during the first World War, the price of platinum was comparatively high; therefore the use of this metal was limited to a few applications as a purely ornamental finish. This also explains why the literature on the deposition of the platinum metals has always been rather meager. Most of the information and formulas given in textbooks refer to platinum and there are only indications given that similar solutions could be used for palladium and rhodium.

When during the early years of this century, white gold began to come into vogue, the jewelers very soon found themselves confronted with the serious problem that all of the white gold alloys, particularly those which contained nickel as the whitening metal, discolored after a relatively short time. To overcome this serious drawback, the jewelry manufacturers resorted to flash-plating white gold articles with metals which promised to give some protection. Strange as it may seem, even chromium and tin deposits were used for this purpose on expensive white gold jewelry. Both metals, however, were objectionable, the former on account of the blue color and the lack of throwing power, and the latter because it stained light-colored dresses. The only logical solution of this problem was the use of platinum as a tarnish-preventing coating, and perhaps only the high cost of the metal at this time and the lack of reliable formulas for platinum plating solutions account for the delay in its general application.

After the discovery of a rich source of supply of platinum metals in certain Canadian nickel ores, the prices were lowered sufficiently to invite renewed interest of manufacturers and finishers.

Most applications of electrodeposited platinum metals today are for ornamental or decorative purposes rather than for protective purposes. Very little work, and mostly experimental, has been done on electroforming with the platinum metals. In this field palladium seems to be the most promising of the six metals, due to its low specific gravity and its low price. The main difficulty encountered is the high affinity of palladium for hydrogen, a certain amount of which is always codeposited with the metal, causing warping or deformation of the electroformed piece.

An increased demand for white and tarnish-resisting finishes during the past ten or fifteen years, together with a concurrent decrease in the cost of platinum metals, have stimulated the research work in this line as is evidenced by the great number of patents[1] issued since 1927.

Rhodium, in particular, has found an ever-increasing number of applications as a finishing metal, despite its high price as compared with platinum and palladium. The explanation may be found in the hardness and brilliant bluish-white color of the rhodium deposit and in the fact that rhodium-plating solutions are easy to operate, are not very critical in regard to current conditions, and have excellent throwing power. As to future developments, it seems that the use of rhodium will remain predominant over the other platinum metals. However, since the supply of rhodium is limited, it is desirable to improve the known platinum solutions and also to develop the use of plating palladium by itself or in combination with other metals. Atkinson[2] describes a method of codepositing palladium with either cobalt or nickel.

Platinum

The oldest known and most widely used platinum plating solution dates back to a French patent granted to Pilet in about 1883. In his formula, platinum is present in solution as chloro-platinic acid, $H_2PtCl_6 \cdot 6H_2O$ (commonly referred to as "platinum chloride"). In preparing the bath, this

† This article is Pre-print 80-40 of The Eleectrochemical Society, New York and due acknowledgment is made to The Electrochemical Society as the original source.

1. Baker & Co. Inc., U. S. Pat. 1,981,820; 1,947,180; 1,779,457; 1,949,131; 1,779,435; 1,906,179; 1,921,941; 1,991,995; 2,027,358; 1,901,531; 1,970,950; 1,993,523; 1,906,178; 1,981,715. British Pat. 408,244; 440,938. German Pat. 564,088; 527,264.

2. U. S. Pat. 1,981,715.

salt is boiled with sodium phosphate ($Na_2HPO_4 \cdot 7H_2O$) and ammonium phosphate [$(NH_4)_2HPO_4$] for a considerable time. During boiling, the color of the solution changes from orange-red to pale yellow. The precipitate of orange-colored ammonium platinic chloride [$(NH_4)_2PtCl_6$] which forms in the beginning gradually disappears. The change in color indicates the formation of a complex amino-phosphate of platinum. A bath formula of this type recommended by Pfanhauser is as follows:[3]

Pfanhauser Platinum Bath

	1 Liter	1 gallon
Water		
Di-ammonium phosphate, $(NH_4)_2HPO_4$	20 g.	2.2 oz.
Di-sodium phosphate, $Na_2HPO_4 \cdot 12H_2O$	100 "	13.4 "
Chloro-platinic acid, $H_2PtCl_6 \cdot 6H_2O$	4 "	0.535 "

Since this solution contains only 1.5 g./l. (3.7 pennyweight/gal.) of metallic platinum, it is intended mainly for flash plating.

The ammonium and sodium phosphates serve as conducting as well as buffer salts; the former also provides the NH_3 radical necessary to form the amino complex. The amount of either salt is not critical. The platinum amino complex is ionized to a very small degree only. For this reason the cathode efficiency is very low, about 25 to 30%, and basis metals immersed in this solution do not cause a deposit by electrochemical displacement. The solution is operated close to boiling temperature and at approximately 3 to 4 volts. The current density under these conditions is about 1 amp./dm.^{2} (9.3 amp./sq. ft.). Bright flash deposits can be obtained in from 30 to 120 seconds, after which time the deposit becomes cloudy and finally dull gray. With increased metal concentration, somewhat higher current densities can be used. Platinum anodes are used but the metal content of the bath must be maintained by the addition of platinic chloride. This, of course, means that the platinic chloride has to be transformed into amino complex by prolonged boiling, as described above, after the addition of ammonia or ammonium phosphate.

It is obvious that, by replenishing the platinum of the bath as indicated above, the chloride content of the bath increases rapidly and it very soon reaches a concentration where the deposit becomes black and powdery and the bath has to be discarded. Another disadvantage of this type of bath is the yellow insoluble precipitate formed on the anode, which necessitates frequent interruption and filtration. The cathode efficiency is not constant and specified amounts of deposit cannot be repeatedly produced by merely observing the current and time. Accordingly, the articles being plated have to be weighed from time to time.

Another type of plating bath based on the same formula as above uses platinum diamino nitrite (platinum "P" salt) instead of the chloride. This bath has a longer useful life since no chlorides are introduced on replenishing the platinum content; otherwise this bath shares with the Pfanhauser bath the objections due to the insoluble precipitate and the inconstancy of the cathode efficiency.

As an improvement on the above platinum diamino nitrite bath, the following formula is recommended:[4]

Keitel and Zschiegner Bath

Ammonium nitrate, NH_4NO_3	100	g./l.	13.4 oz./gal.
Sodium nitrite, $NaNO_2$	10	"	1.3 "
Platinum diamino nitrite, $Pt(NH_3)_2(NO_2)_2$	16.5	"	2.2 "
Ammonia, NH_4OH (28% soln.)	50	"	6.7 "

The platinum diamino nitrite is separately dissolved by heating it in a 5% ammonia solution; thereby the diamino salt is changed into the readily soluble tetramino salt $Pt(NH_3)_4(NO_2)_2$, which is then added to the bath. This K. and Z. bath is also operated near its boiling point and should be kept ammoniacal by replacing at intervals the ammonia lost through evaporation. Flash plates can be obtained from this bath in from 30 to 60 seconds at from 4 to 5 volts. In order to build up heavier platinum deposits, a low current density of 0.44 amp./dm.^{2} (4.1 amp./sq. ft.) at about 2.4 volts is recommended. The platinum of the bath is replenished by the addition of platinum diamino nitrite dissolved in ammonia. No objectionable salts are introduced by this procedure. Ammonium nitrite reacts with sodium nitrite according to:

$$NH_4NO_3 + NaNO_2 \rightleftharpoons NH_4NO_2 + NaNO_3$$
$$NH_4NO_2 \rightleftharpoons N_2 + 2H_2O$$

The cathode efficiency of this bath also is inconstant and, accordingly, the articles being plated must be weighed from time to time in order to determine the actual amount of deposit.

During the operation of this K. and Z. bath, the NO^-_2 ion concentration tends to increase, due perhaps to cathodic reduction of the NO^-_3 ion. Any increase in NO^-_2 ion will in turn hold back the ionization or dissociation of the platinum complex and will therefore reduce the platinum metal ion concentration, resulting in a decrease in cathode efficiency. Cases have been observed where the metal deposition ceases entirely. Addition of some ammonium nitrate and vigorous boiling of the bath will gradually decompose excess nitrate and will restore the bath to proper working order. In all of the bath formulas mentioned above, neither the metal concentration nor the concentration of conducting salts is very critical. In most cases a metal concentration of about 2 g./l. (5 dwt./gal.) should be sufficient. Whenever heavy platinum deposits have to be formed, it is advisable to use higher metal concentration.

As a rule, the deposits from all of the above platinum plating solutions are slightly brighter at a pH of 7 or slightly below. Decreasing the pH much below 6.4 may cause peeling, which is particularly true for the nitrate-nitrite bath.

The use of addition agents for purposes of brightening the deposit has, up to the present, not been very successful. In this connection it must be remembered that most organic substances, when added to the bath, will eventually reduce the platinum compounds to the metal. Platinum anodes are used in all baths. The basis metals to be plated should be cleaned in the usual manner by electrocleaning, cyanide and/or acid dips.

For reasons of economy it has become common practice to apply a nickel undercoat. This is necessary whenever lead, tin and zinc alloy articles are to be plated. Since platinum deposits are used mostly for ornamental purposes, and for these flash plates suffice, no special thickness tests

3. W. Pfanhauser "Elektrolytische Metallniederschlage," p. 512-514, Springer (1922). Blum and Hogaboom, "Principles of Electroplating," p. 372-373, McGraw-Hill Book Co., New York City (1930).

4. Keitel and Zschiegner, U. S. Pat. 1,779,436, assigned to Baker & Co. Inc.; Trans. Electrochem. Soc. 59, 273 (1931).

are needed and no specifications have as yet been set up. The only exception is in the case of white gold jewelry. Whenever the word "platinum" appears in the hallmark, the stamping law requires a platinum deposit of 5% by weight of the article. When heavier than flash deposits of platinum are applied, they have to be scratch-brushed intermittently. Due to the codeposition of hydrogen, platinum deposits are, as a rule, hard and brittle and therefore difficult to polish. The buffing wheel used should be charged preferably with an aluminum oxide or a chromium oxide compound.

Palladium

Electrodeposits of pure palladium have as yet not found any industrial application. The oldest practical formula for a palladium plating bath is given in a patent by Pilet[5] (1884) which is analogous to the one given by the same author for platinum.

Pilet Palladium Bath

Palladous chloride $PdCl_2 \cdot 2H_2O$	3.7 g./l.	0.5 oz./gal.
Di-Sodium phosphate, Na_2HPO_4	100 "	13.4 "
Di-Ammonium phosphate, $(NH_4)_2HPO_4 \cdot 12H_2O$	20 "	2.6 "
Benzoic acid, $C_7H_6O_2$	2.5 "	6 dwt./gal.

This solution is boiled until the dark red color is changed to a light yellow, indicating the formation of a complex amino palladium compound.

Palladium deposits can be obtained from this solution at 50° C. (125° F.) and at about 1 to 2 volts, and a current density of 0.2 to 0.3 amp./dm.^{2} (1.8 to 2.8 amp./sq. ft.). Under these conditions the deposit remains bright for short plating periods but soon becomes cloudy and dull. Platinum or palladium anodes are used, neither of which are attacked. Replenishing palladium in the bath is through additions of palladous chloride and subsequent boiling until the original color has again changed to light yellow.

Here again, the introduction of the amino nitrite of the metal has during the past fifteen years offered certain advantages as outlined above for the corresponding platinum salt. Using the same formula as the Pilet one above, but replacing the palladous chloride with the palladium amino nitrite, the useful life of the bath can be considerably increased since no chlorides are accumulated during plating operations and the cathode efficiency remains at about 90%. It is important, however, to hold the current density just below the gassing point; otherwise, dark and powdery deposits will result.

Palladium can be plated directly, or over a flash nickel undercoat, on most metals or alloys, with the exception of zinc, tin and lead alloys, in which cases a heavy nickel undercoat is essential.

The concentration of the salts of the palladium amino nitrite bath is not critical. The metal content can be increased for making heavier deposits, without changing the characteristics of the deposit or the plating conditions. The pH is preferably kept at about 7.0 by adding ammonia from time to time. Deposits obtained at a pH below 7.0 may be slightly brighter but have a tendency to peel.

The patent literature of the past ten years lists a great number of palladium bath patents;[6] however, upon checking the claims experimentally, it has been found that many of them are inoperative or impractical.

As mentioned before, palladium offers some advantages over the other platinum metals, particularly as regards specific gravity and low price. It should therefore find some application when heavier deposits are called for. For decorative purposes, the color may be objectionable. Palladium, although tarnish- and corrosion-resistant, is attacked by nitric acid and slowly by hydrochloric acid.

Rhodium

Even though a few references to the electrodeposition of rhodium are found in the literature prior to 1915, this metal was never used to any extent for plating purposes until 1930.

The first attempts to plate with rhodium employed the commonly known rhodium salts such as the chloride or the sulfate. Although deposits can be obtained from these solutions, they are far from satisfactory. A rhodium bath made up according to an old Pilet formula using rhodium chloride with a mixture of sodium and ammonium phosphates yielded deposits of steel-blue color and had an extremely poor throwing power. A number of patents[7] have been issued for rhodium plating solutions, covering alkali double nitrites in acid or alkaline solutions, rhodium sulfate or chloride in combination with corresponding alkaline salts and free acid and rhodium amino cyanides.

In general it may be said that only acid electrolytes will give a bright, white deposit and at the same time show good throwing power. The solutions which have been most successful in this country are of the acid type. They comprise rhodium sulfate dissolved in dilute sulfuric or phosphoric acid, or rhodium phosphate in combination with some acids. While rhodium sulfate is a well defined compound of the formula $Rh_2(SO_4)_3 \cdot 12H_2O$, there seem to exist a number of rhodium phosphates of a more or less complex nature to which no definite formulas can as yet be assigned.

Upon attempting to isolate these complex phosphates in salt form they undergo changes, or decompose, making identification difficult, if not impossible. It is only by rigorous and scientific control during rhodium salt manufacture that a constant and uniform product can be obtained. This also explains why rhodium for plating purposes is now sold in the form of concentrated solutions.

The rhodium plating solutions in practical use today, whether rhodium sulfate or rhodium phosphate, usually have a metal concentration of 2 g./l. (5 dwt./gal.). This concentration is entirely arbitrary and has been adopted as a compromise, keeping the initial investment and the drag-out losses low and having at the same time enough metal in solution for quick coverage at a reasonable cathode efficiency.

The acid concentration is not very critical and can range from 10 cc./l. (1.3 liquid oz./gal.) upward for either sulfuric acid or phosphoric acid. Higher acid concentration tends to lower the cathode efficiency slightly.

A representative formula for a rhodium plating bath as used today is:

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5. U. S. Pat. 330,149.

6. U. S. Pat. 1,993,623. Brit. Pat. 408,244; 367,588. German Pat. 564,088; 614,801. U. S. Pat. 1,981,715.

7. Baker & Co. Inc., U. S. Pat. 1,949,131; 1,981,820; 2,057,475; 2,057,476; 2,067,534; 2,067,747. Brit. Pat. 413,342; 438,365; 370,539. German Pat. 667,199. Colin G. Fink and G. C. Lambros, Trans. Electrochem. Soc. **63**, 181 (1933).

Rhodium Plating Baths

1. Sulfuric acid concentrated, C.P.	20 cc./l.	2.523 liquid oz./gal.
Rhodium metal in prepared concentrated solution	2 g./l.	5 dwt./gal.
or		
2. Ortho phosphoric acid (85%)	40 cc./l.	5 to 6 liquid oz./gal.
Rhodium metal in prepared concentrated solution	2 g./l.	5 dwt./gal.

It is important in making up either bath to add the acid to the water before adding the rhodium. If this is not done, the rhodium compound may be partly precipitated by hydrolysis. Even if the precipitate may gradually go into solution again, the bath will not yield white deposits.

The best working temperature is around 40° to 45° C. (110° to 125° F.). A current density of from 1 to 11 amp./dm.^{2} (10 to 100 amp./sq. ft.) may be used. Insoluble platinum anodes are used, and the metal content is replenished by the addition of the concentrated rhodium solution.

A good rhodium solution of this type should produce a bright deposit of approximately 0.00015 cm. (0.00006″) in 30 min. at 2.2 amp./dm.^{2} (20 amp./sq. ft.) which does not require buffing. The throwing power approaches that of a gold or silver cyanide bath.

Fig. 1 and 2 are based on tests with a standard rhodium plating bath containing 20 cc./l. (2.5 to 3 liquid oz./gal.) of concentrated sulfuric acid, C. P., and 2 g./l. (5 dwt./gal.) of rhodium metal in the form of the commercially available complex phosphate. The curves of Fig. 1 show the effects of bath temperature and current density on cathode current efficiency. The curve in Fig. 2 shows the relation between rate of deposition and the metal concentration of the bath.

It has become common practice to use a nickel or bright nickel undercoat for rhodium, except in the case of gold alloys and platinum bases. Zinc, tin and lead alloys must receive a good, heavy nickel undercoat so as to completely protect the basis metal from the action of the rhodium solution. This holds true when plating rhodium from either the phosphoric acid or sulfuric acid bath.

Rhodium deposits are characterized by their high reflectivity, the ratio of reflected light to incident light being 78%. The hardness of the plate ranges between nickel and chromium. In most cases rhodium is applied as a flash plate averaging less than 0.0000025 cm. (0.000001″) in thickness. For silverware and for high-grade reflectors for searchlights (some are 1.5 m. in diameter) and for motion picture projectors, a plate up to 0.000018 cm. (0.0000075″) in thickness is recommended.

Ruthenium

The following formula has been recommended[8] for a ruthenium bath:

Ruthenium nitroso chloride, $RuNOCl_3$	4 g./l.	10 dwt./gal.
Concentrated sulfuric acid, C. P.	20 cc./l.	2.5 to 3 liquid oz./gal.

Current density, 2.2 amp./dm.^{2} (20 amp./sq. ft.)
Voltage, 2.5 volts.
The color of the deposit is rather dark.

8. Baker & Co., Inc. U. S. Pat. 2,057,638.

Analytical Methods

Analytical methods for the exact determination of the platinum metals in plating solution are somewhat complicated, due to the highly complex nature of the compounds in the bath. Accordingly, highly specialized methods of analysis are employed. As long as the solution is not contaminated with other metals, the platinum metals can be determined by electrolysis, that is, by "complete depositing out," but the results thus obtained will, as a rule, be short of the actual amounts present.

In the case of rhodium solutions, colorimetric methods have been worked out and a kit containing the necessary materials and apparatus is available. The results thus obtainable are accurate to about 0.1 to 0.2 g./l. provided the plating solution to be tested is not contaminated by other metals.

Silver Coatings by Vapor Condensation

New applications of silver coatings applied by vaporization methods have been found recently and appear likely to increase when their properties and relatively low cost become more widely known. A coating only 0.000005″ in thickness is substantially opaque and has the characteristic appearance of silver, of course, as well as other properties, such as high reflective ability, which silver possesses. Tarnishing of the exposed surface must be avoided in most cases, but this is possible under many conditions. Applications on transparent plastic sheeting has possibilities and such coatings have brilliant luster when viewed through the plastic, making the sheeting applicable in place of tin and aluminum foils, for example, at least for some purposes. Naturally, such films are not entirely free from porosity but this is true of nearly all thin films, however formed.

Transparent molded plastic coated on the under side or inside with a thin silver film can be given the appearance of silver and yet be light in weight and have the other properties of plastic. The same is true of glass parts, as far as appearance is concerned, and the brilliance of a mirror is secured. Reflectors, especially those of glass, are now being coated with silver in large quantities, especially where the surface is later subject to and kept under high vacuum, as in lamp bulbs of certain types and in vacuum bottles. Under such conditions, silver is displacing aluminum, needed for other purposes, and provides higher reflecting properties. Silver can be coated onto refractories having dielectric properties to form condensers many of which are needed in radio and related applications.

Silver can be applied by several other methods besides that involving vaporization. Many particulars concerning these methods are available in records compiled by the American Silver Producers Research Project, now directed by Handy & Harman, and can be had by interested manufacturers.

Metals of Antiquity

PART I

By JOSEPH DANFORTH LITTLE

Much has been written about the antiquity of metals and much has been left unsaid. It is extremely doubtful if a complete story can ever be told. Any article written on metals, even after intensive research, must still leave the subject unexhausted, for the relation of metals to man is limitless. There is no branch of history of civilization which tells us how man advanced from the Stone Ages to the Metal Age of today, with its highly developed industries and complex organization. Metals have played an important part in the civilization of man. They have been used by man for over 10,000 years and metal work is one of the earliest forms of craft work.

THE art of metallurgy was practiced by all nations of the past that reached any degree of civilization. The earliest historical books of the Bible show that even nomadic tribes, in their desert wanderings, were able to carry on the art of metallurgy, fifteen to twenty centuries before the Christian era. To appreciate the metals which have been put in the earth for the use of man, we must know something of their origin. The earth as a whole consists mainly of metal but the most of it is situated in the interior and therefore is inaccessible. We are ignorant as to the time when man made his debut upon the earth. The only records we have of man during the very early metal ages are what are found, from time to time, in the remains which have been unearthed in caves or sites, where he led a precarious existence, or in the rivers, gravels, and the like.

Back in the dim past, when the western races were still struggling to free themselves from the throes of barbarism, the Orientals were already accomplished in metal arts and crafts. They seemed to have appreciated, almost from the beginning, the beauty of silver and gold and also copper and its alloys, brass and bronze, and to have understood the wear and corrosion resistance of these metals. As a medium of artistic expression, these metals peculiarly fitted the temperament of these people who were like the metals, seemingly unaffected by the passing of time. The world of today owes a debt of gratitude to the earliest users of those metals, for without them our knowledge of the culture of the distant past would be very much less extensive than it is. Archeologists, by dint of patient searching, find relics that, bit by bit, make it possible to piece together the story of once flourishing nations and cities, that no longer exist. Frequently the only traces of a vanished civilization are preserved in precious and semi-precious metals, while everything else has turned to dust.

Prehistoric Man's First Acquaintance with Metals

Meteorites were perhaps the first metal known to man. The "falling stars" were found to be a better "stone" than any earth-given and archeologists tell us that the ancient Oriental peoples, at an early date, learned to fashion these "stones" into useful implements. Meteors are, so we are told, nothing but broken chips of demolished planets which came within the attraction of the earth and it stands to reason that these planets must have been composed chiefly of iron and allied metals. Most meteors are composed of 95% or more of iron, tempered to the consistency of steel, especially the largest, weighing many hundreds of tons.

As to how man first came to a knowledge of the common

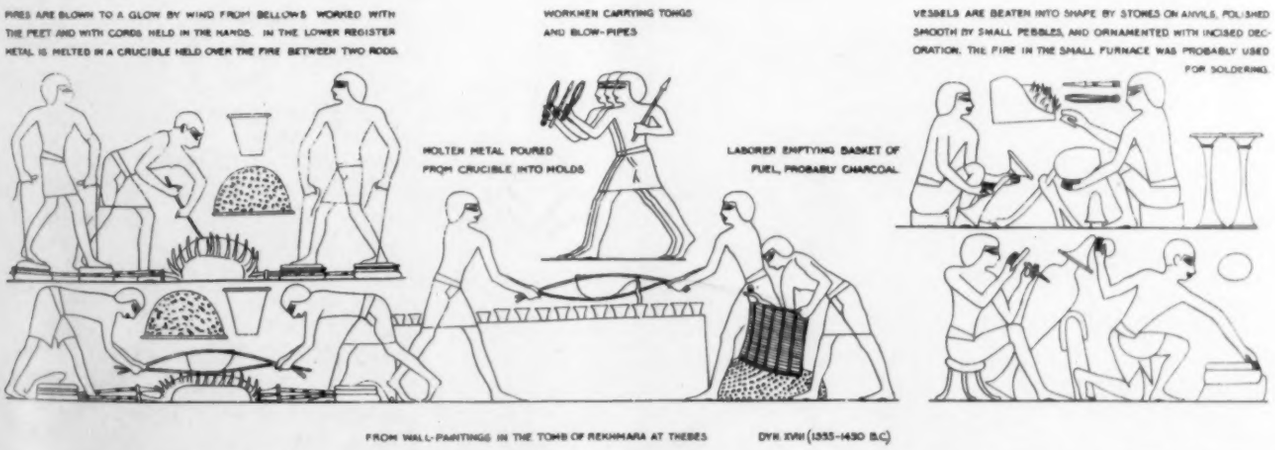
FIRES ARE BLOWN TO A GLOW BY WIND FROM BELLOWS WORKED WITH THE FEET AND WITH CORDS HELD IN THE HANDS. IN THE LOWER REGISTER METAL IS MELTED IN A CRUCIBLE HELD OVER THE FIRE BETWEEN TWO RODS.
WORKMEN CARRYING TONGS AND BLOW-PIPES
VESSELS ARE BEATEN INTO SHAPE BY STONES ON ANVILS, POLISHED SMOOTH BY SMALL PEBBLES, AND ORNAMENTED WITH INCISED DECORATION. THE FIRE IN THE SMALL FURNACE WAS PROBABLY USED FOR SOLDERING.
MOLTEN METAL POURED FROM CRUCIBLE INTO MOLDS
LABORER EMPTYING BASKET OF FUEL, PROBABLY CHARCOAL
FROM WALL-PAINTINGS IN THE TOMB OF REKHMARA AT THEBES DYN. XVIII (1555-1450 B.C.)

Fig. 1. Drawing illustrating Egyptian workers in metals of 2500 years ago. This is from a wall painting in the tomb of Rekhmara at Thebes. Eighteenth Dynasty (1535-1450 B.C.).

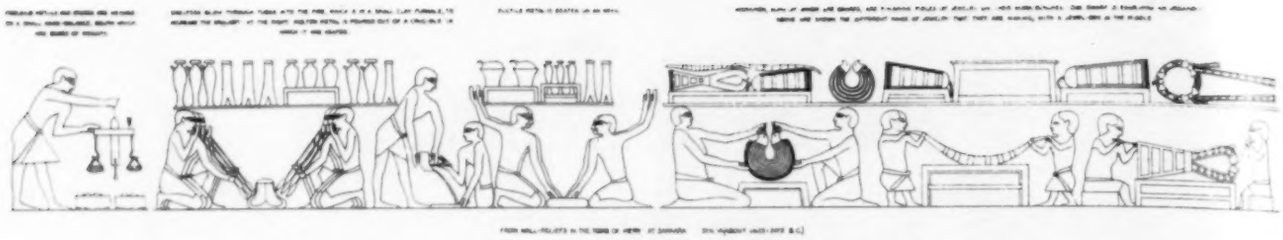

Fig. 2. Egyptian metal workers of 4000 years ago. From a Sixth Dynasty Fresco in the tomb of Mery at Sakkara (about 2625-2475 B.C.) The drawing illustrates weighing, smelting and working. Dwarfs were frequently employed because they were easily apprehended in case of loss.

metals is shrouded in the obscurity of the dawn of civilization. Prehistoric man undoubtedly fashioned his weapons, first from wood and bone, then later from stone, and still later, as he advanced, he used metals.

Gold, which was widely distributed, was probably the first metal known to the human race. This was without doubt on account of its brilliant color, easy workability, and because it occurs so frequently in the metallic state. It served chiefly as an ornamental material and was not suitable for weapons or utensils.

Copper was probably the first useful metal known to prehistoric man and it was used at a very early period by all ancient nations. The earliest known records of a civilization are found in Babylonia, in the district of Mesopotamia, where a people of Semetic origin settled about 8,000 to 10,000 B. C. Records of ancient Babylonians date back to some 6,000 years B. C. Articles of copper are found alongside of gold ornaments and stone tools, in the most ancient Babylonian (Chaldean) ruins.

Some of the metals occur native, but it is not logical to suppose that all the metals used by the ancients were of this kind. In the Old Testament scriptures, gold, silver, copper, iron, lead and tin are mentioned; also brass, although copper or bronze are probably meant.

The Art of Refining Known to the Ancients

The art of refining in furnaces seems to have been known long before the Christian era. Aristotle, Herodotus, and Pliny make frequent references to the abundance of silver which existed in their day. Aristotle tells us that in return for domestic necessaries, the natives of Tartessus presented him with more silver than he could manage to stow on board his vessel. Pliny, who was born in 23 A. D. and succumbed to the suffocating vapors from the eruption of Vesuvius, in 79 A. D., which buried Herculaneum and Pompeii. Discorides, the Greek physician, who also lived at that time, gives fairly accurate accounts of the smelting operations of their times but he did not explain the chemistry of these processes.

Herodotus, "the father of history" who has been accused of having been the world's foremost liar, praised the temple of Belus, with its golden statues of Jupiter, Juno, and Rhea and its beautiful censers and cups of the same metal. The inhabitants of India, we are told, were familiar with production and use of metals early in their history. We are told that they made swords and axes of iron as early as 1500 B. C.

The early Romans understood the art of working in metals and made armor, tools, implements, and coins. Most of the metal came from Spain. Primitive metallurgical processes are referred to in some of the oldest known historical records, which indicate to us that metallurgy, as a science, must have been long practiced as an art. The discovery of metals must have revolutionized the habits of the people who lived in the stone age.

From earliest times, man has fashioned his domestic utensils from elements, provided by Providence, ready to hand, in their natural state, such as flint, stone, clay, wood, silver, gold, iron, copper, and by copper we have in mind bronze and brass, which are alloys of copper.

Factories were known in ancient times. There were brick factories in Babylon, a sword factory in Athens, and factories in Italy making arms and armor.

In our museums and collections may be found metallic weapons, coins, and utensils of various sorts whose antiquity in undoubted. Many of them long antedate the Christian era and show that the people of those remote times and civilizations had a certain amount of knowledge of the art of metallurgy in both its branches: i.e., they knew how to extract metals from their ores and they knew how to fashion them for use.

The increasing use of metals and the progress of civilization are very closely allied. It would be impossible to continue living in comfort and luxury as we do if metals were removed. In this day and generation we take many things for granted, paying little or no attention to the foundation laid by ancient workers.

Tubal-cain the First Metallurgist

Tubal-cain, who lived about 4,000 years ago, appears to have been the first metallurgist of which we have any record. Sacred scripture tells us that it was he who brought the metalcraft to his people (Gen. 4, 22). It says he was "an instructor of every artificer in brass and iron." He is described as having lived seven generations from Adam.

Ancient Tools

For the most of us there is a fascination about ancient things. We can not help wondering how the workman of old, especially the worker in metals, accomplished what he did, with comparatively limited knowledge and crude tools with which he worked. Concerning the tools of early man, the record is scant but the tools of the craftsman of that day remain and many of the things they made still exist, to bear witness of their skill and ability. Many of the ancient tools used by early man are older than any other fact we have learned of ancient man himself. Tools have been found in graves, in beds of streams, or buried under the earth, which hark back nearly a million years. The most ancient tools were not even made—they were found.

Smooth flat pebbles, worn by the water, were chosen because they fitted the hand. Bits of hard shell and splinters of flint were undoubtedly used to scrape flesh from hides and bones but before that there must have been a time when there were no tools at all. What could the world have been like in those early days when tools, fish-hooks, knives, axes, or spear heads were unknown? The first tools man used were probably of flint and these old tools indicate to us, that the skill of these early tool makers was extraordinary, for they made knives, spear-heads, drill-points, and even saws. After many changes in this old world metal tools appeared, and on down through the ages came tools of copper, bronze, iron and steel.

The Ancient People Were Traders

At a very early period, commerce was carried on between nations widely distant from each other. The productions of one country were bartered for those of another and spread all over the known world by means of ships and caravans. Men were influenced by much the same motives in those times as they are at the present, and hence gold, silver, copper and other metals were supplied to peoples and tribes who had none in their own territory. Invasion and conquest led to the accumulation and dispersion of wealth and it is apparent that gold, silver, etc., were formerly produced where they are not now to be found.

The illustration shows the complete progress of the ancient Egyptian metal industry, from the delivery of the ore to the casting of the metal in moulds. The men in the top illustration are making a fire and putting on or taking off the crucible. The pictorial records, which are preserved to this day, show bellows and the method of blowing, in the upper and middle scene. These bellows were probably the oldest mechanical device for the purpose and were used in the time of Thothmes III. They consisted of two leather sacks or bags fitted into simple supporting frames from which long pipes were carried to the fire. The pipes were first simple reeds with metal nozzles but later metal tubes were substituted. Two workmen, each of whom is standing on a pair of bellows, work the bellows by treading alternately first on one and then on the other, the top of the exhausted bellow being pulled up by a cord, so as to become inflated. With a backward and forward movement, the workman can keep up a steady blast without a great deal of effort. Bellows of exactly the same general type were used by the Egyptians, in later days, in the production of iron. The picture is much too early to have anything to do with iron. In the bottom picture, men are bringing various ingredients of the melt, presumably ore, and materials, for reduction and flux, the process being carried out in a crucible having a spout, by means of which the reduced metal is finally poured into a row of ingot moulds on the left.

The use of metals in Egypt harks back to the dawn of history. Before the art of weaving was known, copper pins, about two inches long with loop heads, were being made. These were found in graves which archeologists tell us are over 4,000 years old. One of, if not the oldest metal weapons known, is a copper dagger, having two rivet holes for the hilt. This weapon was found in a grave, at Negada, earlier than the first dynasty. At this time and considerably later, copper only was used. Bronze did not occur until the Fourth Dynasty, about 3,100 B. C.

The Wonderful Gold Work Found in the Tomb of Tutankhamen

The discovery, in 1924, of the tomb of Tutankhamen (B. C. 1358-1351) and other more recent discoveries give ample proof of the basic value and progress of metal work. In the tomb of Tutankhamen, when the two outer coffins which were covered with sheet gold had been removed, the remarkable inner coffin, of solid gold, was brought to light. This not only demonstrated the capacity for symbolic expression and the wonderful efficiency of the goldsmith of those far-away days, but the prolific manner in which gold and precious and semi-precious stones were used. The innermost coffin of gold, which contained the actual mummy of Tutankhamen, would be valued today, at the present price of gold, as being worth over $350,000. It is six feet in length, magnificently engraved both inside and out, and embellished with auxiliary cloisonne work of gold and semi-precious stones, such as turquoise, lapis-lazuli, and carnelian. The coffin is now in the Cairo Museum.

We marvel at the surprising ability shown by the craftsmen who were responsible for this wonderful creation. Over the head and shoulders of the mummy a magnificent golden mask was found, which represents the eighteen-year-old boy king. This was made of solid beaten gold and as mere bullion, at the present price of gold, would be worth $3,500. Many other rich and rare treasures were found, such as gold perfume boxes seven inches high, gold clasps, gold rings and toilet articles, a throne with gold embellishments and a chariot entirely overlaid with beautiful golden repousse panels, inlaid with semi-precious stones, faience, and colored glass. The wonderful examples of creative ingenuity, by members of the goldsmiths craft, found in the tomb beggar description.

One cannot help wondering what our workers in precious metals of today would do if they were commissioned by governmental authority to produce gold and silver objects that would equal or excel those of a people who so skilfully worked the precious metals and who have left such abundant stores as proof of their artistry and technical ability, as well as their culture. They also found articles of brass, such as a brass drain pipe and brass ornaments.

Fig. 3. Photographs of ancient drinking cups made of silver. About 300 B.C.

The Incas Were Wonderful Workers in Metals

In South America, archeologists have dug their way 7,000 years into the past and found deep in the soil beneath ruined Inca temples, articles of beauty and utility that stand today as mute testimony of a once mighty American civilization. They found weapons and tools and artistic religious articles of a highly cultured people, all fashioned out of copper. To the durability of copper can be credited today's knowledge of the daily life of the Incas. The copper objects found indicate to us that this ancient race was completely familiar with the process of deriving metal from ore, and that they were very proficient in every branch of metal casting.

Copper knives, an axe still sharp, sledge-hammers, fish-hooks, and many curious instruments whose purposes have never been defined, were unearthed in the heart of Colombia in South America. They also made copper jewelry, finger rings, and bracelets ranging from plain copper to the most gorgeous execution. Strange to relate, the religion itself of this ancient people seems to have been identical with much of that of the later Egyptians. The worship of strange nameless gods is exemplified in beautiful instruments, face masks, replicas of animals and birds, also human figures in miniature, showing grotesque deformities. These were all fashioned from 5,000 to 7,000 years ago by these interesting people and have survived when almost all other trace of the Incas has disappeared.

A—Descending into the shaft by ladders. B—By sitting on a stick. C—By sitting on the dirt D—Descending by steps cut in the rock.

Fig. 4. Drawing of an ancient mine taken from "De Re Metallica" by Georgius Agricola.

Ancient Mines

History does not tell us when and where the first mines were dug. They have been known from the earliest times in Egypt, India and in Spain. The mines in Spain were rich in copper, gold, silver, lead, iron, tin and mercury. One of the oldest mines in Spain, that is being worked today, furnished eight hundred thousand pounds of silver, which was an annual tribute to Rome and the piles of slag and rubbish around the mines would indicate that they had been worked for centuries.

One old writer who lived over two thousand years ago tells of the mines in Egypt, where captives of war and even those who had been unjustly accused by evil persons were condemned to work both day and night under a guard of foreign soldiers, who could not speak the language of the condemned workers. This was done so that no guard would be moved to pity through the pleadings of the workers. Not only were those who were strong and in good health obliged to work, but the aged, the women and the children were compelled to work in chains under the blows of the overseer.

The legends of the "Iliad" and the "Odyssey" of Homer (900 B. C.) indicate that the Greeks were familiar with common metals, even in the prehistoric period. At that time they also had iron as well as copper. Iron was mined and manufactured in Crete and Cyprus and many other Greek islands. The Greeks mined lead and silver at Laurium, at Attica, as early as 550 B. C., and when Athens was at the height of its power as many as 6,000 slaves were employed in the mines. These mines belonged to the state but were rented out for short periods to private operators, who worked them with slaves. Greek writers have called it a place of dread and terror, where men died like flies.

The Phoenicians worked the mines of Spain, or Huelva as it was known, and later they were succeeded by the Romans who worked the mines for over 400 years or about to 412 A. D. The annual production of copper by the Romans, we are told, amounted to 2,400 tons. The Phoenicians also found silver in such quantities that they loaded their ships with it to the water's edge and even made anchors of it.

We are told much about ancient mines in a book published in 1556 by Georgius Agricola who was born in Germany in the fifteenth century. A translation of his book has been made by Ex-President and Mrs. Herbert Hoover. A copy of this may be found in many of our public libraries. In this book called *De Re Metallica*, Agricola tells us the story of mining in his day and also the story of mining centuries before, as it came to him from the folk tales and traditions of his country. He shows with great care and exactness the methods and processes used in his day and describes the tools used, the processes of crushing, washing, smelting and assaying of ores and metals. He also tells about the small mines in the mountain country of his day where the ore was

taken out and stored until winter came. It was then placed on sleds and these were guided down the mountain side by the miners. At some of the mines the ore was put into sacks of pig skin, which the miners dragged down the mountain by hand, in places where it was too steep for horses or mules. In winter they would sometimes slide down the mountain, sitting on their sacks, and guide these with a stick, "not," says Agricola, "without risk."

Alloys

The facts regarding the development of the art of preparing new metals by melting together several other metals are very meager.

Both profane and sacred history tell us that metallic alloys which we call "bronze" were not uncommon. Pliny, who lived about A. D. 23, tells us that a flourishing trade was carried on in Rome shortly after the founding of that city and that Numa, the immediate successor of Romulus, formed all the workers of this alloy into a kind of community or guild. The ancient Greeks possessed considerable knowledge in the art of mixing metals and knew how to prepare alloys with special properties which rendered them suitable for particular purposes.

The oldest alloys we know always contained copper, which is, no doubt, due to the fact that this metal occurs native in many places and is also readily reduced from its ores. Undoubtedly, the alloys of copper with tin, generally called bronze, were the earliest mixtures of metals. Next came alloys of precious metals with each other and with copper. A common alloy of the ancient world is rarely made today. It was known as "electrum," a mixture of gold and silver, much used for ornaments and statues. We are told that the first known coins were struck upon electrum, a natural alloy of gold and silver. This was about the year 669 B. C. Electrum, however, being a natural alloy, varied a great deal in the proportions of gold and silver it contained, so it remained for Croesus, who became King of Lydia in 561 B. C., to perfect the system of separating these metals. This potentate, famous in ancient story and song as the richest man that ever lived, followed the precedent at the beginning of his reign by striking coins of electrum, but soon adopted a new system issuing gold and silver coins which could be easily exchanged.

Copper—One of Man's Oldest and Most Useful Metals

Copper has been known from the remotest ages. It is found in many parts of the world in an almost pure state. Some authorities tell us that copper was known and used by primitive man 10,000 years ago. Studies of the most ancient and most primitive ruins indicate that the metallurgy of copper was practiced, in its crudest form, in the earliest periods of man's development. He evidently found that, on account of the ease with which it could be smelted, refined, and worked, it was a most useful metal for his weapons and tools. It could be hammered with a stone hammer when cold, and when heated it could not only be hammered but cast. Neither the name of the man who discovered the reduction of copper by smelting nor the method he employed will ever be known because he lived long before men began to make records of their discoveries and doings.

The discovery of smelting copper was probably accidental. Prehistoric man, it is thought, made the discovery when he built a primitive fireplace and when it happened that among those stones the bright green ore of copper was used as a stone, a lump of metal that could be hammered, was found. This man of the stone age discovered that it made a far better tool than the stone one that he had up to that time been using. Copper, by reason of its rather frequent occurrence in its free state and also its malleability, ductility and readiness to form alloys, found early use and was for a long time employed for a purpose for which iron has since been used.

In Cyprus, mining debris and vast mounds of ancient slags are found in many localities. In early days Cyprian copper was not only famed in the time of Homer but it was sent as a tribute to Egypt, several centuries earlier. According to the inscription on the tombs of Thotmes III (about 1500 B. C.), the copper from Cyprus was received as a tribute in Egypt in the form of vases and other vessels. It is said they were of elegant design and workmanship. Copper has been closely interwoven with most of the arts of war and peace by all the great nations of the world.

When we read of the numberless articles of priceless value which existed before history began to be recorded and which perished long ago, we can not help heaving sighs of regret. The melting pot has been the worst enemy to articles of copper, gold and silver and also bronze, but we are thankful for what has come to light in ancient ruins such as Herculaneum and Pompeii and those which have been found in the ancient Egyptian tombs. Numerous examples of bronze stopcocks and other plumbing accessories are found in the Naples museum among the Pompeiian collection.

In some of the early graves of Ur in Mesopotamia, which date back to 5500 B. C., both copper objects and also bronze objects have been found. In the Museum of the University of Pennsylvania in Philadelphia are a number of copper and bronze objects from Ur which are between 4,000 and 5,000 years old.

The Egyptians used copper before the Christian era and many museum specimens of copper in the form of tools and weapons are thought to be still earlier. They appear to have been the first in the field in artistic bronze casting, for objects of cast bronze are in existence which hark back to a period as early as 3,000 B. C. The pyramids of Egypt were made with the aid of tools of bronze and stone. Millions of tons of stone were cut in the quarries of the upper Nile and shipped down the river to the building site, shaped and set in place and all that work was done with tools of bronze and stone. One historian, Diodorus by name (B. C. 60-25), tells us that it required the labor of three hundred and sixty thousand people for over twenty years in building but one of the pyramids.

The Chinese were acquainted with the art of moulding and chiseling bronze from their earliest antiquity. In the reign of Yu, in the Hsia dynasty (2205-1767 B. C.) the record has been kept by her own students of art, shows that something very notable, indeed a kind of triumph, had already been achieved in bronze casting by this wonderful nation. Copper was the chief metal of ancient China, and gold and silver were chiefly employed for decorations, being inlaid or incrusted. Copper was not often employed alone but mixed with an alloy of tin and became bronze. There is a record of a standing figure, made at the com-

mand of the reigning Emperor (469 A. D.) of Sakyamuni, for a Buddhist Temple, which contained 135,000 pounds (67½ tons) of copper and it was overlaid with 8,000 pounds of gold.

Research in Cyprus shows that it produced copper as early as 3,000 B. C. The copper mines of ancient Spain were worked as early as 2,000 B. C. Bronze was used as early as 1,000 B. C. for making vessels and utensils of many kinds. Pliny, who was born in 23 A. D., speaks of vases made of brass and tells us that they were considered more valuable than if made of gold, on account of the beauty of the metal and its fitness for chasing and sculpture and other modes of ornamenting. The remains of Mycenaen, Phoenician, Babylonian, and Assyrian civilizations stretching over a period of 1500 to 500 B. C. all yield many copper and bronze objects. The old Trojans were equipped with brass weapons.

Copper and Brass in Sacred Scriptures

There are a great many references to brass in the sacred scriptures which are undoubtedly due to faulty translation, either bronze or copper being meant. Copper and brass are mentioned over one hundred times and many authorities think there is little doubt but that copper is intended in passages of our translation of the Bible where mention is made of brass. In Ezra (Chap. 8-27) two vessels are mentioned "of fine copper as precious as gold." Early in sacred scripture (Gen. 4-22) we find reference to Tubal-cain as the first artificer "in brass and iron" and a marginal note gives brass the alternative reading, as copper.

Brass was often obtained by the joint reduction of ores of copper and zinc and not made, as in our day, by careful alloying of free metals. When King Solomon built a temple described in the Bible (1 Kings, Chap. 6) he caused to be erected "the molten sea to catch the holy water from heaven . . . a bowl." It rested on the backs of twelve oxen and was about nine feet high and fifty feet in circumference. This he describes as brass, although it may have been of bronze, as the words brass and bronze were used interchangeably. In Deuteronomy (Chap. 8, V. 9) it speaks of digging brass from the hills. Evidently mining operations were not unusual in those early days. In Judges (Chap. 16, V. 21) it speaks of Samson, the Israelitish hero, being bound with "brass fetters."

In 2 Chronicles (Chap. 4, V. 9 to 19) it tells of Hiram making many articles of "brass" and some are made of "bright brass." Mention is made of the door of the court being "overlaid . . . with brass," and made of "bright brass" were "pots, shovels and flesh hooks."

Much has been written about the so-called art of tempering bronze, supposed to have been practiced by the men of the Bronze Age in the manufacture of their weapons. The hardness has also been considered greater than can be given to bronze at the present day. This is an erroneous impression, for the ordinary bronze of today can be made as hard as any, in fact harder than most, of prehistoric times by simple hammering alone.

A report, published in 1769, speaks of the deepest mine in England, which was a copper mine, at Ecton Hill, in Stratfordshire, and it says it was 1200 feet deep from the hill top to the floor of the mine. Some sixty men worked there in six hour shifts, receiving two pence the hour. Women, boys and girls also worked here. After the ore was broken up, it was taken by little boys to the sheds in wheelbarrows. They received five to ten cents a day. Little girls sorted the ore and received the same pay. The ore was then broken with hammers, used by the women, who received ten to twenty cents a day. The same writer tells us that the mines were owned by the Duke of Devonshire, who made a clear profit of between $40,000 and $50,000 each year.

Iron

Iron is the most common and the most useful of all metals. Pure iron is seldom used for making things, as it is too soft for nearly all practical purposes. Man has only to purify gold and silver, but he has, as it were, to "create" iron, and this art harks back even beyond The Deluge, for we read in sacred scripture (Genesis 4, 22) "Tubal-cain, an instructor of every artificer of brass and iron." He, being the first metallurgist on record, should be the patron saint of every worker in iron.

Excavations at Great Zimbabue, in Mashonaland, South Africa, seem to prove that the iron industry flourished in the interior of Africa before 2,500 B. C. or some 2,500 years before the use of iron was known in Europe. Some authorities claim that the use of iron antedates that of any useful metal, others that bronze, or brass as it was called, is still older. Whether the iron age is older or younger than the bronze age is of little consequence to us now. We know that, in our economic life, iron is far more valuable to us than bronze. Of all the heavy metals in the world, iron is by far the most common and the most useful. It is said that the very core of the earth is made up of iron.

Man discovered in very early days that iron could be worked into a tool or weapon by a method so simple that even primitive and savage tribes have known how to do it. Bits of iron have been found in ancient Egypt and Mesopotamia. The British Museum has a small bit which came from the Pyramids in Egypt and it is thought to be over 5,000 years old.

Iron is mentioned in sacred scripture some seventy-five times. It is first mentioned in connection with Tubal-cain (Gen. 4, 22) and it is mentioned many times in the Old Testament. One interesting allusion to it is found in Deuteronomy (Chap. 3, V. 11) which tells us about King Og who, it appears, was the inventor of and had the first iron bedstead. It reads, "For only Og, King of Bashan, remained of the remnant of giants; behold his bedstead was a bedstead of iron." The Canaanites had chariots of iron (Joshua 17-16). Job was acquainted with iron and its uses, for he writes (Chap. 20-24): "He shall flee from the iron weapon and the bow of steel shall strike him through." Moses alludes to iron frequently and compares the bondage to a furnace for smelting iron. It says "the Lord hath . . . brought you out of the iron furnace, even out of Egypt." Iron was known and used by the Hebrews for we find that iron is mentioned thirteen times in the Pentateuch. The Philistens are stated to have deprived the Israelites of their smiths (Kings 24-14) and in the time of David, about 1000 B. C., iron was somewhat in general use. During the building of Solomon's Temple the use of iron tools was forbidden. "Neither hammer nor axe nor any tool of iron was heard in the house while it was building" (1 Kings 6-7).

Relation Between Tap Water and Plating Efficiency †

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WATER is the commonest of all raw materials used in plating and metal processing. Platers may wonder about material shortages and about solution maintenance as it affects the concentration and composition of the principal ingredients aside from water. Seldom, however, if at all, is water given much attention. Of all the variables present in plating, and you have heard about a lot of them—those present in water are given the least consideration. This implies that tap water, as used by platers, is stable, definite in composition and the same thing day in and day out, irrespective of season, location or source. The purpose of this paper is to show that lack of consideration should definitely not be the case. Through presenting a comparatively brief outline on water and the relation between water composition and plating efficiency, it is hoped that some respect for these variables may be given in the interest of better cleaning and plating practice.

Production of Water

Let us begin by first considering the production of water. There are two sources of water—natural and artificial. In the synthetic production of water, hydrogen and oxygen may be fused together in the ratio of two parts hydrogen to one of oxygen, forming molecules of water. The neutralization of an acid and an alkali will produce water and a salt. Many compounds exist as hydrates and crystals which contain water in their structure which may be distilled through the application of heat. All of these methods are, however, chiefly of scientific interest. It is that water which is extracted by solar evaporation from natural containers (lakes and oceans are the largest reservoirs or containers) which we are chiefly concerned with.

This water, which is condensed in the form of clouds and finally precipitated as rain or snow, is comparatively pure, aside from air-borne impurities. But as it flows downward over the earth's surface, it becomes contaminated by the water soluble materials in the soil which it contacts. From this it can be seen the composition of water will differ according to the soil from which it has been secured. It should also be apparent that there will be differences within the general range of impurities of water from a given source or district according to seasonal occurrences such as rainfall, floods and dry spells, or artificially produced conditions caused by water control projects such as dams and aqueducts, chlorination, etc.

Now because the subject of water control and analysis seems to have been overlooked by most platers, it should not be inferred that other users of water have likewise disregarded it.

James P. ApRoberts

They have not, nor has this been overlooked by certain firms supplying materials which are used in aqueous (water) solutions or methods for treating and equipment used in connection with such solutions. In fact, much of the data in this article are directly or indirectly the result of information published by some of these firms and what has been confirmed or developed through several years' work in water analysis at the laboratory where the writer is employed.

The results of these findings regarding the contaminants introduced into plating and cleaning solutions by various waters and their effect upon solution life and efficiency may be divided into several phases. However, in order to do this and at the same time gain a familiarity with the general subject of water chemistry, let us first consider what those contaminants are and some of the terms used in discussing them.

Contaminants

The most common of these impurities are calcium, magnesium and sodium compounds, carbonates, bicarbonates, sulphates and chlorides, and oxides of iron, aluminum and silicon. There are also minor, usually insoluble impurities such as insoluble matter and organic substances. The attached report covering a group of four such analyses lists the above in an arrangement which shows their relative occurrence in water from the vicinity of Turco's Los Angeles plant. It is included for this reason and also to bear proof of the statements made regarding variance in water composition.

In going over this sheet you will notice that certain terms have been

† Presented at the 8th Annual Meeting of the Los Angeles Branch, American Electroplaters' Society, March, 1942

Local Water Conditions on the Following Dates

	Los Angeles, Cal.						
	Nov. 14, 1941	Dec. 1, 1941	Jan. 15, 1942	Mar. 20, 1942			
Free carbon dioxide	0	0	0	0	ppm	as	$CaCO_3$
½ bound carbon dioxide	61	60	31	64	"	"	"
Total carbon dioxide	244	242	128	264	"	"	"
Hydroxides	0	0	0	0	"	"	"
Normal carbonates	0	1	4	8	"	"	"
Bicarbonates	122	120	62	128	"	"	"
Total alkalinity	122	121	66	136	"	"	"
pH	8.0	8.6	8.1	8.1			
Calcium hardness	17	0	0	34	ppm	as	$CaCO_3$
Magnesium hardness	221	342	393	222	"	"	"
Temporary hardness	61	60	31	64	"	"	"
Permanent hardness	177	282	328	192	"	"	"
Total hardness	238	342	359	256	"	"	"
Calcium hardness	1	0	0	2	gpg	as	$CaCO_3$
Magnesium hardness	13	20	23	13	"	"	"
Temporary hardness	4	3.5	2	4	"	"	"
Permanent hardness	10.5	16.5	19	11	"	"	"
Total hardness	14.5	20	21	15	"	"	"
Sulphates	40	40	90	20	ppm	as	SO_4
Chlorides	20	20	35	30	ppm	as	Cl
Crystalloidal silica	30	30	30	30	ppm	as	SiO_2
Colloidal silica	10	10	60	10	"	"	"
Total silica	40	40	90	40	"	"	"
Iron	Nil	Nil	Nil	Nil			
Alumina	Low	Low	Mod.	Low			
Turbidity	Nil	Nil	Nil	Nil			

employed as a means of expressing the degree of contamination or for discussing certain types of contaminants. They are part of the terminology of water chemistry. Just as platers speak of throwing power, anodes, strike dips and other unusual sounding problems, so do water chemists adjust the English language to their own purposes. Sometimes these words have an entirely different meaning than what might be normally implied.

For instance, "water hardness" is not measured by the resistance of a water sample to penetration by a sharp pointed device. Instead, this term is applied to the extent of calcium and magnesium impurities present in a water solution. The degree of "water hardness" is commonly measured by the amount in drops or "grains" (one "grain" hardness is equal to 17.1 "ppm" or "parts per million") of a standard soap solution which must be added to react with the calcium and magnesium compounds present in a 50 ml. sample. The end-point, a permanent lather, is based upon the fact that a permanent lather cannot be produced in water which has any degree of "hardness". The opposite of "harden" is "soften". Just as ordinarily this word means the reverse of "harden", so in water chemistry it is applied to the removal of those impurities which cause water hardness. The various methods of water softening will be briefly discussed later.

You have already noticed mention of "parts per million" and "grains per gallon" or "gpg". These two terms are alternately employed to express the quantity of contaminant either on a percentage basis or in their ratio to gallons of water. Ten grains per gallon of water hardness are equal to 17.1 times 10 or 171 parts per million. This expression in turn is the same as saying that 171 particles out of every million will be contaminant. Perhaps the relation between percentage and parts per million can be made clearer when it is understood that 171 parts per million represents 0.0171% of the total composition.

Some of the items on this sheet are listed as "per ppm of $CaCO_3$", ($CaCO_3$=calcium carbonate). In this case, calcium carbonate has been employed as a reference in much the same way that current density is based upon a reference of square feet instead of meters or rods. Thus the data have been converted to an equivalent amount of calcium carbonate.

There are many other terms and expressions used in water chemistry. The forementioned are, however, the most common. If any others should be mentioned they will be defined during the accompanying discussion.

Now, with these fundamental terms in mind and realizing that water as used by platers is definitely not a pure substance, let us consider the effect of those impurities upon the solutions used for plating and processing operations. First in order of plating operations, and hence our consideration, are cleaning solutions.

Here the effect of calcium and magnesium impurities is displayed. Just as in the test for water hardness it was noted that "harder" water required more soap in the form of drops, it naturally follows that likewise more material will be needed to "soften" an entire tank than a beaker-full of water as previously determined by the drop test. This softening effect is a necessary feature of well balanced cleaners.

As platers you are well aware of some of the requirements for an effective cleaner. That is, you judge a cleaning solution by the strength and time required to produce a surface free from water-breaks in addition to its solution life. The choice of a cleaning material rests primarily upon the work to be treated and contaminants encountered.

Unfortunately, many times the contaminants considered by either user or manufacturer of cleaning materials have been those noted on the surface of the work. This viewpoint is erroneous as far as the true operation of aqueous cleaning solutions is concerned for there are actually two major classes of contaminants:—those present on the work and those encountered in the solution. A good cleaning compound will take into account both of these by providing for some means of first eliminating the harmful effects of the calcium and magnesium contaminants as well as others which may be found in the tap water, then treating the soil on the work, which is to be cleaned, by penetration, deflocculation, emulsification, saponification or dissolving it.

The three methods of removing calcium and magnesium impurities from water are by precipitation, conversion into a soluble salt, and sequestration.

Precipitation

The basis for precipitation as a means of eliminating calcium and magnesium contaminants is that either by separate treatment or the action of a precipitating chemical in the cleaner solution, relatively inert and insoluble precipitates of these two elements will be removed from solu-

tion. Soft curds are one example of this type of precipitate that further illustrates this point by the difficulty illustrated in removing scum which they may leave on work. In such cases the salts of calcium and magnesium interact with the soap, which is a salt compound of sodium or potassium and one or more organic acids such as palmitic or oleic. A typical formula for this reaction is the following between calcium sulphate and sodium palmitate [$Na(CO_2C_{15}H_{31})$].

$$CaSO_4 + 2Na(CO_2C_{15}H_{31}) \rightarrow Ca(CO_2C_{15}H_{31})_2 \text{ ppt} \downarrow + Na_2SO_4 \text{ soluble.}$$

Beneficial precipitation treatments rely upon the fact that calcium carbonate and magnesium hydroxide are insoluble and their precipitates may be finally removed from solution by filtration.

The lime and soda treatments for "temporary" and "permanent" hardness utilize this fact as may be seen from the equations following.

For the removal of "temporary" hardness, caused by calcium and magnesium bicarbonates, (deriving its name "temporary" from the fact that the application of heat drives off carbon dioxide and converts the bicarbonate into a carbonate which, as in the case of boiler scale, is deposited on the sides of the container), slaked lime is added in the quantity shown by water analysis to be required to produce the following reaction and convert magnesium sulphate.

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 \downarrow + 2H_2O.$$

"Permanent hardness", or water hardness, represented by compounds unaffected by the application of heat is sometimes removed by the use of sodium carbonate. The two principal compounds which cause this are calcium and magnesium sulphate. The latter will be converted by the addition of slaked lime to insoluble magnesium hydroxide and at the same time more calcium sulphate will be produced. The equation for this is:

$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$$

Then sodium carbonate will react with calcium sulphate to form soluble sodium sulphate which does not have the same harmful effect as calcium sulphate and precipitate the calcium out as $CaCO_3$.

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + Na_2SO_4$$

Any calcium chloride will be removed by this same method and soluble sodium chloride instead of sodium sulphate will result.

When both types of hardness are present, caustic soda (NaOH) may be employed. In this instance, calcium bicarbonate is converted into $CaCO_3$ and magnesium bicarbonate is precipitated out as magnesium hydroxide.

(A) $Ca(HCO_3)_2 + 2NaOH \rightarrow CaCO_3 \downarrow + Na_2CO_3 + H_2O$

(B) $Mg(HCO_3)_2 + 2NaOH \rightarrow Mg(OH)_2 \downarrow + Na_2CO_3 + H_2O$

Magnesium sulphate or chloride is affected in a manner similar to magnesium bicarbonate while calcium sulphate in turn reacts with the Na_2CO_3 produced by equation (A) and (B). Thus:

$$MgSO_4 + 2NaOH \rightarrow Mg(OH)_2 \downarrow + Na_2SO_4$$

Washing soda ($Na_2CO_3 \cdot 10H_2O$) is another means of treating both kinds of hardness.

The effect of sodium carbonate upon calcium bicarbonate has already been noted. The bicarbonate is converted by similar displacement reaction into insoluble calcium carbonate. Magnesium compounds however, are only slightly affected. Hence this treatment, judging from the ratio of calcium to magnesium compounds shown on the preceding water report would not be as effective as one which treated both calcium and magnesium compounds.

Sequestration

A good expression for sequestration, although slightly on the questionable side of technical definitions, might be that it is precipitation as it affects water softening except for the fact that no precipitation is formed. Sequestrants, sometimes referred to as softening agents derive their name from the fact that instead of precipitating hardness as may be the case of a cleaner whose softening power is based upon precipitation at high and usually temporary alkalinities, these materials have the unique property of tying up calcium and magnesium compounds so that they cannot react with soaps which may be either a part of the cleaning material or produced through saponification during the cleaning process. A parallel instance of such beneficial formation of a complex salt is in the case of copper cyanide plating. Copper cyanide by itself is relatively insoluble. The addition of sodium cyanide however, develops a complex cyanide which is more soluble and better suited for plating. As time goes on there will be an increasing use of sequestrants because of the effect which they have upon increasing cleaning efficiency. (Complex phosphates are used as sequestrants.—*Ed.*).

Conversion Into a Soluble Salt

This high sounding term briefly outlines what occurs during water softening operations employing a "Permutit" or zeolite type of water softener. Their processing cycle is usually as follows: The hard water is filtered through a complex compound of oxides of aluminum, silicon and sodium which may for convenience sake be called sodium zeolite or NaZ (not Nazi) the calcium and magnesium compounds are converted into the more soluble and less harmful sodium types. Then, as shown in the second equation, the zeolite or "Permutite" is reclaimed at the end of a given period, usually based upon the probable amount of water which has been so treated. Reclamation is simply accomplished by converting the calcium extracted during operation into calcium chloride by closing off the outlets and pouring in brine. Usually twelve hours, or overnight, will be sufficient time for the unit to become recharged. For large users of water, these units will in a short time, it is claimed, justify their original costs.

Softening: Ca or Mg (hardness radical) + NaZ → CaZ or MgZ + Na (radical).

Reclamation: CaZ or MgZ + 2NaCl = NaZ + Ca or $MgCl_2$.

The calcium and magnesium chlorides are, of course discarded. In this connection however, it might be stated that the use of a chloride solution for recharging these units may introduce chlorides into the water so treated, hence water so treated might be detrimental to certain processing operations particularly plating solutions and electrocleaners.

Water Impurities in Rinsing Solutions

The next step following cleaning operations is usually rinsing. Successfully cleaned work is usually free rinsing. I hope, however, that you will note the use of the qualifier "usually". Whether or not it is regarded as such, of all the operations preceding plating, the rinse has the most to do with successful pretreatment. In spite of

this fact, we are often confronted with instances where blistering, poor adhesion and durability, and possibly spotty deposits may be directly attributed to a disregard of this step in the sequence of plating operations.

The final function of a cleaner is that it must be carried over into the rinse and not have a harmful effect upon that operation, for one of the functions of a rinsing is that the work must be carried over into the plating solution without exerting a harmful effect.

It has been estimated by Hogaboom that for each thousand feet of total surface area, one gallon of solution will be dragged out on the surface of a typical area. A little computation will show us that since there are 231 cubic inches per gallon of solution, 0.231 cubic inches of cleaning solution will be on each square foot of surface area. Dividing this figure by 144, as there are 144 square inches in a square foot, shows that a film of 16 ten thousands cubic inches exists on the work per mean square inch. That, my friends, may seem like a very little, little bit, but when you consider that in plating such a film area is often regarded as heavy, then, the presence of such a barrier must be eliminated. Furthermore, the constant introduction of one gallon of a four to eight ounce per gallon cleaning solution into a medium which is often acid is not to be overlooked. Of course, it is to be admitted that just as one gallon is dragged into the rinse, so also will one gallon be carried into the plating solution following rinsing. . . . But the gallon per thousand square feet carried over from rinsing should not be the same in composition as that from the cleaning tank. There will be a gradual, barely perceptible build-up of cleaning solution in the rinse tank.

Having clarified the relative position of rinse solutions in the plating cycle, let us consider just what contaminants may be introduced from the cleaning tank and perhaps a lesser extent carried over into the plating solution. The operation of cleaning cannot be generally expressed by a single equation. For within a typical cleaning tank, many emulsions and soaps have probably been formed in addition to those which are present in varying amounts, the precipitates from previous cleaning operations which may be interacting. As a general rule, however, the contaminants introduced from cleaning tanks into the rinse are either emulsions or soaps plus some of the cleaning solution itself.

Any harmful effects of the latter must be counteracted by the former. In other words, the cleaner is expected to keep right on cleaning in the rinse tank! By this rather broad statement I mean that the following must occur and the effect of water conditions upon rinsing will at the same time be shown in a truer light.

First, if the rinse tank is maintained at a low pH or is acid, any fatty acids present in carried over emulsions, soaps and cleaning solution will tend to be separated from their original water soluble form and float as an oily slick on the top of the rinse, which will interfere with subsequent cleaning operations. Hence if an acid rinse is to be used it should be preceded by an alkaline or fairly neutral treatment. The practice of relying upon an acid treatment to remove impurities not taken care of by the cleaning solution is all right only insofar as these impurities are definitely insoluble in an alkaline solution. For it may be that they merely require a stronger cleaning solution.

Calcium and magnesium hardness constituents are furthermore soluble in an acid medium. But in an alkaline solution they do their part along with all the other contaminants in affording an interference. Thus the softening agents contained in a cleaner must continue their effectiveness in order to obtain good rinsing. If the rinse tank is operated hot, freedom from scale formation is obtained on the container.

It has been noted by Cleveland[1] that in solutions of relatively high pH (12 to 14) the preponderance of alkali usually enables the cleaner to operate successfully, but where the alkalinities are lower, the good rinsing obtainable by use of a softening agent with a wetting agent makes its inclusion in cleaners essential both because of water conditions and other contaminants likely to be encountered.

Following rinsing there are a number of plating or processing operations which the work may be subjected to. The effect of various contaminants in these solutions is dependent upon the electrolyte used. This fact has already been noticed in the case of chromic acid solutions and I predict that more and more attention will be given this matter.

To bear out this point the following maximum limits for the electrolyte in anodizing (using a chromic acid electrolyte) are mentioned in Navy Aeronautical Specification SR—19c entitled "General Instructions for Protective Treatment of Aluminum and Aluminum Alloys by Anodic Oxidation Process with Amendment No. 1". To quote from this specification they are as follows:

Sulphates (SO_4) . . . . 0.10% maximum
Chlorides (Cl) . . . . . 0.05% "
Insoluble Matter . . . . 0.10% "

These limits you will notice are fairly low, in fact they restrict the number of parts per million of chlorides to 500. Yet, it may be asked, "Well, if local water has only 200 chlorine parts per million, why should I worry?" The answer is one which will serve to explain why water impurities, although measured in parts per million or ten thousandths of a per cent are important. With this particular specification in mind, and I might add that it happens to be the reason why some anodizing is now being done with distilled water.

The answer lies in the following: consider the source of water contaminants aside from those present in the initial solution. This is primarily the rinse tank. If, as is largely the case in treatment prior to plating, a water rinse is used, the water introduced will be fairly similar to that used in preparing the plating solution. (Allowing, of course, for the softening effect of any cleaner which was dragged out of the cleaning solution into the rinse and hence into the plating solution.) However, the picture is somewhat complicated by the fact that evaporation losses must be taken into consideration. Sulphates and chlorides do not vaporize as readily as ordinary water. The most efficient way of removing iron oxides, alumina and silica appears to be by filtration. Organic impurities which accompany fungus growths as in the case of acid copper may be treated with potassium permanganate. However, these contaminants, introduced by the tap water are not removable by evaporation. Hence they will tend to become more concentrated in much the same way that brines are produced. Until, as in the case of rinsing solutions, the degree of contamination becomes fairly constant through the re-

1. Metal Finishing, **38**, 479 (1940).

moval of approximately as much contaminant by dragout loss as is introduced by dragout from the rinse tank and increased through evaporation. Thus when you consider the size of the tank as well as these factors, it is truly remarkable why, first in their own interests and now conservation as well, platers have not paid more attention to the problem of water control.

Nor should merely chlorine contamination of chromic acid solutions be considered. Silver plating is likewise affected by the amount of chlorine contamination together with that occasioned by carbonates which come not only as a result of operation but are also introduced through the above mentioned cause of evaporation. Iron is another impurity often introduced through tap water which can cause considerable trouble as in the case of rochelle salt copper solutions.

You will note that I have only lightly touched upon these contaminants for plating solutions. The reason for this has been to bring them before you and to show you that tap water, although clear and palatable it is not the innocent appearing liquid which some people consider it to be.

May I therefore conclude with these words taken from the section from *Plating & Finishing Guidebook* on "Tin Plating from Alkaline Baths" by Oplinger. "The use of soft water for plating solutions becomes more and more important as time goes on." Time has gone on for some time now.

Two other good articles have been published in past issues of *Metal Finishing* discussing the impurities in water and the effects of these impurities on plating solutions. One of these articles is entitled "Water in the Plating Room", by George B. Hogaboom and was published in the April 1939 issue of Metal Industry (*Metal Finishing*), pages 165-167. The other article is entitled, "The Effects of Water Impurities Upon Nickel Deposits", by Myron B. Diggin and was published in the January 1941 issue of *Metal Finishing*, pages 13-15.

A SMALL ILLUMINATING DEVICE

By CARLETON CLEVELAND

Highland Park, Ill.

A MINIATURE lamp of 154 candle-power, the tiny "Focalite", designed and produced by the Cameron Surgical Specialty Company, Chicago, has found its way into the industrial plant, and is serving in many capacities, — for throwing a beam of light into barrels of guns for examination purposes, for examining mechanical devices of various kinds where it is difficult to examine the inside surface for inspection purposes. Usually it is used in combination with a magnifying lens or telescope. It is also used in difficult assembly work where strong direct light is required rather than diffused light.

The company's slogan has been "To See Is To Know", and a number of original ideas have been used in making devices to carry out this objective. This lamp, the Focalite, was originally designed for use in diagnostic examinations in hospitals and by the medical profession generally, for securing better illumination and for medical and surgical examination of the oral cavity, the ear, nose, rectum, and other parts of the human body. Recently, however, industry has claimed it as its own, for reaching hitherto inaccessible places with illumination and magnification when used by the inspector, workman, and tool designer.

Angled miniature lamp for illuminating difficultly accessible places.

Straight type miniature lamp.

The lamp is less than an inch in length and less than ¼ inch in diameter, and is fitted into a polished metal base which is interchangeable with a variety of handles, each designed to meet certain needs. The lamps themselves are made straight, offset, and hooded.

In producing this lamp, metallizing has played a prominent part. The lamp is first blown and sealed. After inspection for light it is normalized by boiling it in water and allowing to cool in the water, whereupon it is based in Bakelite cement. During the basing operation, the lamps are tested for light direction and then baked for approximately 10 hours at 175°F. and for approximately five hours at 250°F. The lamp bulb is then painted with black, burn-proof lacquer, which forms an anchor for the opaque coat of lead which is sprayed on with a special lead wire automatically fed through an acetylene flame, covering the surface of the lamp. Sprayed metal over the lens is then cut away with a precision tool, and the entire lamp (all but the lens) is painted by hand brushing with a special water- and heat-resisting black lacquer. The metal base is then polished, and after final inspection the lamp is ready for use. It throws a small brilliant white light in any examination or inspection service to which it may be applied. Enclosed entirely in metal, the lamp eliminates reflection and glare back into the user's eyes, is very durable, is resistant to oils and acids, and lends itself to sterilization by boiling.

PLATING AND FINISHING
POLISHING — BUFFING
CLEANING — PICKLING
HOT DIP FINISHES

SHOP PROBLEMS

METAL FINISHING publishes, each month, a portion of the shop problems answered as a technical service to subscribers. The answers given are those of the editor, Dr. W. R. Meyer, unless other initials are given. If any reader can answer any questions unanswered, or can suggest better answers, they will be gratefully received and due acknowledgment made.

Plating of Refrigerator Shelves

Hackensack, N. J.

"Gentlemen:

Re: Your editorial 'Plating After April 1st,' we note in particular on tin you say "certain exceptions are also provided for the tin plating of cans, tinning of wire, tinning of health supplies, etc." Under this exception will it be in order for me to tin the shelves of reconditioned refrigerators which must be done in order to put the boxes in fit condition for resale.

Will it be necessary for my customers to give me a priority rating when sending in dirty shelves to be cleaned and retinned?

W. M."

Answer. Conservation Order No. M-43-2 amended March 17, 1942, definitely bans the use of tin for finishing of refrigerator trays and shelves. These items are included in the so-called "A" list given in the order, and no tin was allowed in the production of any item on list A, effective April 1, 1942.

This order pertains to both new goods and refinishing of used goods.

Plating on Plastics

Vancouver, Can.

"Gentlemen:

We are interested in copper plating plaster cast articles, and have consulted our past issues of *Metal Finishing* for information, particularly the August 1940 issue.

In view of the difficulty of obtaining copper powders, we wish to ascertain if there is available a conducting lacquer or similar fluid which could be sprayed on as a conductor.

Also, is it necessary that acid solutions be used as our present tanks are cyanide formulas? Plating time indicated in the Aug. 1940 article is 8 to 35 hours. We would like some means of shortening this as production would be small on this basis.

Any suggestions or help on this subject would be deeply appreciated.

W. F & Son, Ltd."

Answer:

We know of no conducting lacquer to be used in place of copper powder.

We suggest trying a special colloidal graphite material developed for coating non-conductive surfaces previous to plating. This material can be obtained from Acheson Colloids Corp., Port Huron, Mich. Acid type plating solutions are usually recommended inasmuch as the coatings have considerably less tendency to lift off the plated object than do coatings produced in cyanide solutions. In cases where the bond is somewhat better than on plaster of Paris, such as in coating plastics, it has been found possible to silver plate directly upon a reduced silver film, using cyanide type solutions.

It is difficult to accelerate the rate of plating when plating upon any non-conductive materials because of the temperature limitation factors. However, if you can agitate either the work or the solution, you may be able to double the current densities and reduce the plating time proportionally.

Stripping Nickel from Steel

Lambertville, N. J.

"Gentlemen:

I understand that fuming nitric acid is faster for stripping nickel from steel than ordinary 38°-40° Be. nitric acid.

However, from meager information that I have, it seems that there are several grades of fuming nitric acid.

Kindly inform me what grade of fuming nitric acid is used for this operation.

H. J. B."

Answer. The fuming nitric acid recommended for stripping nickel from steel contains 85-95% HNO_3 of a specific gravity of 1.50 or 48° Be.

Fuming nitric acid of this concentration dissolves 0.001" nickel in 20 minutes, whereas ordinary concentrated nitric acid usually requires about 6 hours to dissolve one-thousandth of an inch of nickel.

Plating on Stainless Steel

Jackson, Mich.

"Gentlemen:

I would very much appreciate if you could give me the basic preparation, if it is possible, to plate either stainless steel or Monel.

H. R."

Answer. Three general methods have been proposed in the literature for electroplating upon stainless steel, and these methods may also be applicable to Monel metal.

The method proposed by Wood involves the use of a solution composed of:

Nickel chloride ..... 32 oz./gal.
Hydrochloric acid, 22° Be. 16 fl. oz./gal.

The work is made the cathode at 6 volts which normally gives a current density from 57 to 75 amp. per sq. ft. Anodes of electrolytic nickel sheet are recommended and treating time varies from 30 seconds to several minutes, depending upon the metal to be treated. This method has also been recommended for obtaining good adhesion on nickel silvers.

H. Shirley in 1937 proposed a method for securing adherent copper deposits upon austenitic chromium nickel steels. This method was described in the March 1941 issue of METAL FINISHING, p. 122. It consists briefly of a cathode reduction treatment in sulphuric acid of concentration 300 g./l. operated at room temperature and with a current density of 27 amp. per sq. ft. After 3 minutes of treating time, with the work as cathode, the article is transferred to an acid copper sulphate solution. Recently, a patent has been granted to the International Nickel Co., 67 Wall St., New York City, for obtaining adherent electrodeposits upon Monel metal. The process involves anodic treatment followed by cathodic treatment in an acidified nickel chloride solution, followed by copper plating in an acid type bath.

Gold Plating Wire

Manitowoc, Wis.

Gentlemen:

We are very much interested in getting a good method to gold plate on silver wire. We have been able to put a very thin plating on this wire but what we need is a 2% gold plate 24K. This we have not been able to accomplish as yet. Can you tell us how to do it?

Our plating tank is about 18" long and is provided with rollers to pass the wire through the bath. We can put 10 ends through at one time. Is it the speed of the wire or is it the anodes which have been our difficulty? We have used solid gold anodes and we understand that carbon anodes are much better. Where can we purchase such carbon anodes?

N. T. Mfg. Co."

Answer:

The amount of gold deposited will depend on the current used and the time the wire is plated. For a 2% deposit by weight, each ounce (troy) of wire will require 5.1 ampere minutes. In other words, if one ounce of wire is in the tank at one time and a current of 1 ampere is applied, the wire should be in the tank 5.1 minutes for the required deposit. A smaller amount of

wire and a larger current will, of course, require a proportionately smaller time.

If the gold solution is in good operating condition and has a satisfactory analysis, the gold will deposit practically at 100% efficiency.

If the capital tied up in anodes is not important it would be better to use gold anodes rather than carbon because in the latter case the gold would have to be added as a gold salt and the cost would be higher per ounce of gold. The carbon anodes also have some tendency to disintegrate and cause roughness of the deposit. If carbon anodes are desired, they can be obtained from practically any supply house.

In any case the trouble is not with the anodes but probably to incorrect operation with respects to current and time.

—G. B. H., Jr.

Peeling of Copper During Polishing

Hamilton, Ontario.

"Gentlemen:

We have been plating gun barrels with a fast plating cyanide copper solution up to 0.015" and 0.020".

When these are ground to size again, the grinder has burnt the plate causing it to crack and lift where burnt. However, after the plate has been fractured, it is very easy to pull the plate off in large strips. What we would like to know is, if this is natural due to the very thick plate, or are we giving them a good adherent plate when this happens.

Please advise us what wheel should be used, so that they will not burn the copper, if possible.

Also if a slight sand blast would help the adhesion of the copper. We have been letting the barrel soak over night in a good alkaline solution and then electric cleaning same, after which we hand scour with acid to neutralize, with the in-between rinsing in clean water. We mention also that we burnish with emery cloth after every 1½ hrs. in the copper solution, and get a very good, not too porous plate.

Do you think it advisable to pickle the barrel in acid before electric cleaning, if so, what would be best.

Could you also advise us the procedure of flake testing electroplating."

R. P. Plating Co.

Answer:

If the adherence between plating and base metal is good, the copper should not peel off when ground, even if it is a heavy deposit. If the adherence is moderately good, the deposit may not peel if it is soft, but it will peel if hard and brittle. Therefore you may have a combination of poor adherence and hard deposit.

Check for hardness or brittleness of the deposit by bending pieces that have flaked off. They should bend back on themselves without cracking. If cracking occurs, then the solution is contaminated or otherwise in need of correction. The use of emery cloth in the solution to burnish the deposit can introduce glue and other materials that may harmfully affect the character of the deposit.

To obtain good bonding, electropickle the steel in 30-40 deg. Baume sulfuric acid, work anodic. (After first removing all oil and dirt).

Follow the electropickle by a dip in a solution of 1 lb./gal. of sodium cyanide at 170° F. This not only neutralizes acid but acts as a mild smut remover. Then rinse and plate. If necessary increase the strength of the cyanide dip.

After plating, if heavy ends or nodules are to be removed, recourse to machining or filing is best. Then bring to finish size by grinding, using a muslin set-up wheel. A solid wheel creates too much heat.

Please advise what you mean by flake testing.

—G. B. H., Jr.

On Government Standards for Cadmium Plating

It was mentioned in the June issue of METAL FINISHING (p. 313) that there was no *general Government* standard on cadmium plating. The letter published below is self-explanatory.

Chula Vista, Cal.

"Gentlemen:

You are mistaken when you say there is no general Government standard on cadmium plating. The Army-Navy specification AN-QQ-P-421a specifies the thickness of parts with and without threads. Among other things which are described in this specification is a method of determining minimum thickness required. This specification must be used by everyone plating parts for the Army and Navy."

Bernard Gross, Process Engineer
Rohr Aircraft Corp.

The following remarks by G. B. Hogaboom, Jr. & Co. on the subject may be of interest.—Ed.

"There are a number of government specifications for cadmium plating rather than a single general specification. Not only do the different departments have their own specifications but one department may have various specifications for a variety of articles.

As examples I can refer you to the following:

Navy: Spec. 46PI (Dec. 1, 1937) "Unless otherwise specified, a minimum thickness of 0.0005" is required except on threaded parts on which a minimum of 0.0002" is required."

Army-Navy Aeronautical: Spec. AN-QQ-P-421 (Jan. 13, 1940). "A minimum thickness of 0.0005" is required except on threaded parts on which a minimum of 0.0002" is required." In addition, the right is reserved by the purchaser to subject samples to a 250 hr. salt spray at 95 deg. F.

Army: Generally a 24 hr. salt spray test is specified at room temperature instead of minimum or average thickness.

Federal Standard Stock Catalog: Specifications vary with different articles. For example:

Spec. FF-H-106 (June 6, 1933) for Builders' Hardware; Locks and Lock-Trim. Paragraph D-10 calls for 0.0004" *average thickness.*

Spec. FF-116a (Feb. 10, 1937) for Builders' Hardware; Hinges. Paragraph D-6b and D-6c calls for 0.0005" *minimum thickness on significant surfaces.*

Here you have 4 different government purchasing agencies, each with its own specifications and the last with different specifications on similar articles such as Builders' Hardware."

N. H.

Finishing Nameplates

Worcester, Mass.

"Gentlemen:

We are enclosing samples of nameplates. One has just been sprayed, the second has been completed by removing the paint from the surface by hard rubbing, etc.

We are particularly interested in eliminating the hand work involved in removing the surface paint, and also in so doing to improve the quality of the surface to that of the third sample."

H. E. F. Co.

Answer:

The following suggestions can be considered:

After spraying, remove all possible paint from type faces with a squeegee, before paint dries.

After paint is dry, remove remainder on letters using a felt wheel. This wheel may be set up with glue and abrasive, or headed with a greaseless compound.

Final coloring can be done with a sewed muslin buff using tripoli or a white silica composition.

To avoid running off of letters and cutting in to the background, use large diameter wheels, or use a stencil to protect the background.

The use of flat disc or belt type machines has the advantage of not permitting damage to the background, but the disadvantage of having to cut the whole type surface flat before all surfaces are uniformly cut down or polished. With the wheel method, only the local area under the wheel is being worked on and the whole plate does not have to be brought to a plane.

—G. B. H., Jr.

Scratches in Gold Plate

Philadelphia, Pa.

"Gentlemen:

We have read with interest the up-to-date applications for better gold plating, but there is one question we would like you to answer for us which we have not been able to get out of any book. This relates to the final polish or finish of the gold plate. After what we think to be a perfect finish, upon closer examination we notice tiny lines or scratches on the surface of the gold plating, visible by viewing at a certain angle, and not necessarily with the reflection of light on it.

Our gold plater is anxious to know whether a correction or remedy can be made

by using a certain buffing compound, or whether by some chance, the surface speed of a wheel can control this surface polish. If there is something you can suggest so that we can eliminate these surface scratches, we would appreciate knowing about it."

—H.T.

Answer:

Obtaining a highly polished, scratch-free gold plated surface is an art. The same materials and equipment used by one man can give perfect results and by another man a very poor job.

For very fine finishes, "platinum rouges" made from levigated alumina are used.

For soft metals, "Domet" and "Canton flannel" cloth wheels are in use.

Your trouble may lie in poor preparation of the base metal, or a granular deposit due to the plating solution being of incorrect composition or dirty, or to dirty conditions at the coloring wheel where grit is picked up from nearby operations.

—G.B.H., Jr.

Cadmium Deposit to Withstand 24 Hrs. Salt Spray

Central Falls, R. I.

"Gentlemen:

Will you please let us know what thickness of cadmium should be plated on steel to withstand a 24 hour salt spray test.

The articles to be plated are cylindrical, ¼" high and 7/16" diameter, with a fine matte surface."

A. S. Corp.

Answer:

For most cases, a cadmium deposit of 0.0002" thickness over steel is considered sufficient to stand up in the 24 hour salt spray test.

Thinner deposits will stand up if the base metal is of good finish and free from imperfections and the plating solution is free from suspended matter. Generally one or more of these conditions are not satisfied in commercial practice.

Conversely, if very poor base metal is being plated, or the deposit is of poor quality due to incorrect solution conditions, a deposit heavier than 0.0002" will be required to stand the salt spray test.

—G.B.H., Jr.

Bright Cadmium and Tin

Canton, Mass.

"Gentlemen:

Can you send me any information on the various steps in doing bright cadmium plating, i.e., rinsing, cleaning bright-dipping, and drying.

Can you also tell me if a bright electrotin plate can be applied to steel or brass, in a stannate solution."

T. D. Corp.

Answer:

You do not state what metal you are cadmium plating, and we assume that it is steel.

First of all, the metal preparation should be such so that all smut is removed from the surface and no undue attack of the steel occurs. If the steel is badly contaminated with oil, pre-cleaning, using solvent, vapor-solvent degreasing or one of the emulsifiable cleaners, is recommended. No water rinsing is required following the first two types of cleaning, but following the emulsifiable solvent cleaning, a good rinse should follow. The work is then electrocleaned, preferably using one of the high current density type anodic cleaners, most of which are very effective in removing any residual smut.

Following this, the work is thoroughly rinsed and given a short pickle in muriatic acid, composed of 1 volume of acid and 2 volumes of water, and to which preferably has been added one of the addition agents designed to inhibit attack upon steel. After rinsing, the work is then given a dip in a sodium cyanide solution, 3 oz. per gal., and can be transferred directly to the cadmium plating solution.

For bright cadmium, we recommend the use of one of the proprietary bright cadmium plating solutions. Cadmium plating solutions as well as addition agents are discussed in the 1942 Guidebook, in case you wish to make your own solution. After plating, the work may be brightened further by using one of the several patented bright dips, which are also discussed in the Guidebook.

The type of drying depends upon the volume of work and size of work. In some cases it may be blown dry. In others, sawdust is used, and also centrifugal type driers with blasts of cold and hot air are used.

In regard to bright electrotin plating, we do not know of bright deposits being obtained from the stannate type solution, although considerable work is being done on other type solutions. It is possible to apply a bright tin coating by immersion, upon copper and brass, by the stannous chloride-sodium cyanide-caustic soda dip described in the 1941 Guidebook.

Plating of Aluminum

Elmsford, N. Y.

"Gentlemen:

We are interested in obtaining a bibliography of references regarding the electroplating of aluminum upon other materials.

Any information which you can give us on this general subject will be appreciated.

S. Corp."

Answer:

Regarding electroplating of aluminum, there is little literature on the subject.

To the writer's knowledge, aluminum has not been electrodeposited from aqueous solutions, although one company in Philadelphia reports that they have succeeded in doing this, but no actual observations of the plating process have been made by the writer.

Aluminum has been deposited from fused salts and from non-aqueous solutions. R. D. Blue and F. C. Mathers published a paper in Volume 65 of the Transactions of the Electrochemical Society, 1934, describing a process for depositing aluminum from an electrolyte composed of aluminum dissolved in ethyl bromide and benzene.

This paper contains a bibliography on the electrodeposition of aluminum, the bibliography being up to date as of 1934. There have been some other papers published on the electrodeposition of aluminum alloys but these alloys were also deposited from non-aqueous solutions.

Attaching Handles to Knives

Miami, Fla.

"Gentlemen:

Will you be kind enough to advise us of the best method of fastening handles to knives, forks, etc. We are doing silver plating work now and have to do some repairing at the same time.

S. Pltg. Co."

Answer. Litharge-glycerine cement is usually used for this job.

The materials are mixed by slowly adding the litharge to the glycerine. Stir until the mixture is free from lumps, and add more or less litharge so the mixture will flow when poured into handle.

Fill the handle and insert blade using a jig to hold the blade in alignment with the handle, and allow to set before disturbing the jig. Usually an extra long tang is provided on the blade and it is obvious that only cement enough should be mixed that will be immediately used.—H. W. S.

Circular of the Bureau of Standards on Making of Mirrors

In the June issue of METAL FINISHING, it was stated that Circular No. 389, Bureau of Standards, entitled, "The Making of Mirrors by the Deposition of Metal on Glass" by I. C. Gardner and F. A. Case, could be secured by sending 5c in coin to the Bureau of Standards, Washington, D. C. Royal F. Clark has kindly pointed out that this publication costs 10c and is sold by the Superintendent of Documents, Washington, D. C., rather than by the Bureau of Standards. We wish to thank Mr. Clark for calling our attention to this error.

Talk by W. W. McCord

Syracuse, N. Y.

"Gentlemen:

We should like to know if you have available a reprint of the talk by Wm. McCord on 'The Present Situation in the Electroplating Industry—as regards Government Restrictions and Government Business'.

S. Silver Co."

Answer: The talk by W. W. McCord entitled, "This Country is at War", was published in the June 1942 issue of the *Monthly Review* of the American Electroplaters' Society.

Inquiry should be made to W. J. R. Kennedy, editor, 93 Oak Grove Ave., Springfield, Mass.

Patents

Copper Plating from Refinery Electrolyte on Chromium Alloys

U. S. Pat. 2,285,549. A. Wesley & H. R. Copson, assignors to International Nickel Co., Inc., June 9, 1942. A process for utilizing copper refinery tank house electrolyte containing antimony in amounts greater than 0.1 g./l. to produce adherent copper coatings capable of withstanding forming, which comprises anodizing at 20 amp./ft.² for about 2 minutes in a solution of about 36 g./l. of hydrochloric acid and about 240 g./l. of nickel chloride, then making the iron or nickel alloy containing chromium cathodic under the same conditions of current density and time, transferring to a first copper bath containing about 200 g./l. of copper sulfate and about 100 g./l. of sulfuric acid and substantially devoid of antimony in amounts sufficient to reduce the adherence of the deposit below 9,000 lb. per. sq. in., plating about 0.001 inch of copper, then treating anodically for about 3 minutes at about 13 amp./ft.² in an impure copper electrolyte of the type described above, then making it cathode and depositing a relatively heavy layer of copper.

Plating on Chromium Alloys

U. S. Pat. 2,285,548. A. Wesley, assignor to International Nickel Co., Inc., June 9, 1942. A process for producing adherent coatings of copper on chromium containing alloys of iron and/or nickel to stand forming operations, which comprises treating an alloy containing about 79% nickel, about 7% iron and about 13% chromium in a solution of about 240 g./l. of nickel chloride and about 36 g./l. of hydrochloric acid, as anode, using a nickel cathode, at 70° F. and 20 amp./ft.² for 2 minutes, then making the article cathode at 20 amp./ft.² until a protective layer of nickel has deposited, then transferring to a copper plating bath containing about 200 g./l. of copper sulfate and about 100 g./l. of sulfuric acid and plating at about 50 amp./ft.²

Brushing Machine for Metal Strip

U. S. Pat. 2,278,944. W. M. Quigley and E. S. Taylerson, assignors to Carnegie-Illinois Steel Corp., Apr. 7, 1942. An apparatus for brushing metallic strip during its longitudinal movement.

Zinc Plating Cast Iron

U. S. Pat. 2,277,664. R. O. Hull, assignor to E. I. duPont de Nemours & Co., Mar. 31, 1942. Zinc can be deposited on ferrous articles on which the hydrogen overvoltage is so low as to interfere with the deposition of zinc, such as cast iron, malleable iron and some kinds of hot rolled steel, by first immersing for not less than 5 minutes in an aqueous solution of not less than 2 oz./gal. of sodium cyanide at a temperature of 65° C. or higher, then transferring to a cyanide zinc plating bath without a rinse.

Example:

For cast iron pipe fittings:

Sodium cyanide	30 oz./gal.
Time	15 minutes
Temp.	100° C.

Plating on Printing Cylinders

U. S. Pat. 2,278,512. A. A. Egli and C. Bokenkamp, assignors to Langbein-Pfanhauser-Werke A. G. (Germany), April 7, 1942. A weighted roller device, which automatically adjusts its position along the surface of a rotating cylinder to which an electrodeposit is being applied and smooths and hardens the plated surface so that the deposit is readily etchable for printing purposes.

Electrolytic Polishing

U. S. Pat. 2,282,350. C. L. Faust, assignor to Battelle Memorial Institute, May 12, 1942. An electropolishing solution comprising an aqueous solution of sulfuric acid and orthoarsenic acid, the combined acid concentration being at least 50% by weight and the balance being largely water.

Example:

	1	2	3
Sulfuric acid	36%	25%	10% by wt.
Arsenic acid	47%	69%	77% by wt.
Water	17%	6%	13% by wt.

Temp. = approx. 60°C., Anode current density = 50-100 amp./ft.² and up to 1.000 amp./ft.² Time = 20—90 minutes.

Electrolytic Polishing

U. S. Pat. 2,282,351. C. L. Faust, assignor to Battelle Memorial Institute, May 12, 1942. An electropolishing solution comprising an aqueous acid solution containing from 5 to 93% arsenic acid, from 0 to 85% sulfuric acid and a significant amount of an acid selected from the group consisting of phosphoric and chromic acid and mixtures thereof, said electrolyte having a combined acid concentration of at least 50% by weight, the balance being largely water.

Example for copper and brass:

Arsenic acid	84%
Chromic acid	10%
Water	6%

Copper: 385 amp./ft.², 55°C. 15 minutes anodic.

Brass: 340 amp./ft.², 63°C., 8 minutes anodic.

Example for stainless steel and copper:

Arsenic acid	15%
Orthophosphoric acid	60%
Water	25%

Stainless Steel: 250 amp./ft.², 50-70°C., 40 min. anodic.

Copper: 500 amp./ft.², 50-70°C., 23 minutes anodic.

Example for brass:

Arsenic acid	15%
Orthophosphoric acid	55%
Chromic acid	3%
Water	27%

500 amp./ft.² Time = 30 minutes anodic.

Example for aluminum:

Arsenic acid	25%
Sulfuric acid	15%
Orthophosphoric acid	35%
Chromic acid	10%
Water	15%

50—1,000 amp./ft.², 50-75°C., Time = 5—90 minutes anodic.

Immersion Tin Bath

U. S. Pat. 2,282,511. J. C. Bradley, assignor to The American Brass Co., May 12, 1942. The method of coating cuprous surfaces with tin which comprises treating with an aqueous solution containing stannous tin, upward of about 50 g./l. of thiocarbamide and a small amount of an alkali metal carbonate, at a temperature of about 120°F.

Example:

Stannous chloride	10 g./l.
Thiocarbamide	80 "
Hydrochloric acid	20 cc./l.

Time in minutes	Thickness of tin in inches
1	0.000024
2	0.000037
3	0.000047
4	0.000053
5	0.000060

Coloring Stainless Steel

U. S. Pat. 2,283,170-1. C. Batcheller, May 19, 1942. A method of producing a design on the surface of stainless steel which comprises coating with a resist, etching the design and then subjecting to the action of a solution containing sulfuric acid, water and an etching-inhibiting-oxidizing agent to produce a dark coloration.

Among the inhibitors are chromates, dichromates, vanadates, metavanadates, manganates and permanganates. For etching the designs, solutions of ferric chloride are generally used.

Example:

Etching-inhibiting-oxidizing agent	10-14% by wt.
Sulfuric acid	36-50% " "
Water	40-50% " "

Temp. = 180-210°F. Time = 15-20 minutes.

Nickel Bath

U. S. Pat. 2,284,629. E. M. Baker, assignor to Houdaille-Hershey Corp., June 2. 1942. The method of depositing a ductile, adherent, lustrous nickel using a solution consisting essentially of nickel sulfate and nickel chloride and 25-40 g./l. of sodium formate at pH 3.6 to 4.0.

Example:

Nickel sulfate	240-300 g./l.
Nickel chloride	35- 50 "
Sodium formate	25- 40 "
Boric acid	25- 40 "

pH—3.6-4.0

Temp.—135-145°F.

C. D.—40-60 amp./ft.²

Agitation is preferable, as is the addition of a wetting agent such as 0.2 g./l. of Duponol M.E. dry, and Nekal BX.

Barrel Plating

U. S. Pat. 2,290,036. J. V. Davis, assignor to The Udylite Corp., July 14, 1942. A machine for handling articles automatically in bulk through processing tanks.

NEW EQUIPMENT AND SUPPLIES

NEW PROCESSES, MATERIALS AND EQUIPMENT FOR THE METAL INDUSTRY

Chemical Resistant Paint

Harrington Paint Co., Inc., 1630 Collamer Ave., E. Cleveland, Ohio, have announced the development of a chemical resistant paint called, "Rust Eeter No. 66".

It is claimed that this paint has high resistance to strongly corrosive acids and alkalies, and thus is recommended for coating of plating tanks and exhaust equipment. It is stated that the paint withstands, for example, strong solutions of nitric, sulphuric and hydrochloric acids as well as 50% hydrofluoric acid. It is also reported to withstand sodium and potassium hydroxide solutions up to 50% in concentration.

The coatings are stated to withstand dry heat up to 400°F. and wet heat of not more than 200°F. The paint is applied in not less than three coats for heavy chemical attack. It dries in a few minutes in warm weather and in about 1 hour in cold weather.

The material is available in black and Indian red and is made from domestic and available raw materials.

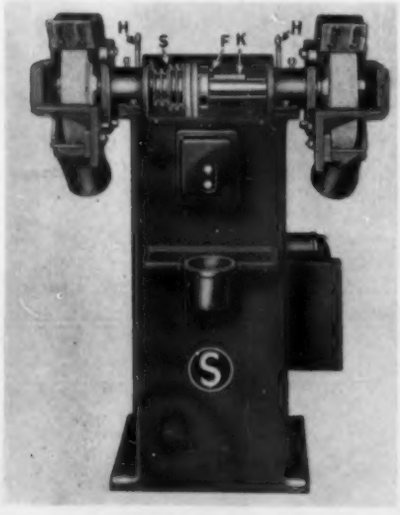
A booklet is available describing the paint.

New Multi-Speed Grinder

The Standard Electrical Tool Company, Evans and Eighth Sts., Cincinnati, Ohio, has added to its line a new "Multi-Speed" grinder.

This machine has not only the speed-change construction but has the added advantage of being able to receive wheel stubs from larger machines which were formerly discarded, thus providing additional wheel economy.

As shown in the illustration, this grinder permits wear of a 12-inch diameter wheel to a 5-inch diameter maintaining the peripheral speed throughout the life of the wheel. The ball-bearing, totally enclosed motor is mounted on an adjustable plate on back of the pedestal with power being transmitted to the grinding spindle through a multiple V-belt drive. A push button safety starter is located conveniently on the front of the machine.



Multi-speed grinder.

Safety guards are of the hinge door type, each with an exhaust outlet, adjustable spark breaker, and work rest. All constructed in accordance with American Engineering Standards.

An interlocking arrangement prevents overspeeding of grinding wheels. Other multi-speed grinders made by the company are available for vitrified or high speed wheels up to 30-inch diameters.

Plating Saves Large Turbine Shaft

Five thousandths of an inch of copper plating recently averted a threatened shortage of electric power in the busy Boston war production area, the Electroplating Division of the Du Pont Company recently announced.

A vertical steam turbine in a local power plant developed a bad "chatter" and had to be shut down. The stoppage came as producers were increasing their demands for electric power.

Investigation showed the shaftway running through the center of the turbine's rotating field had so worn that the rotating field did not fit snugly enough on the 35-ton shaft.

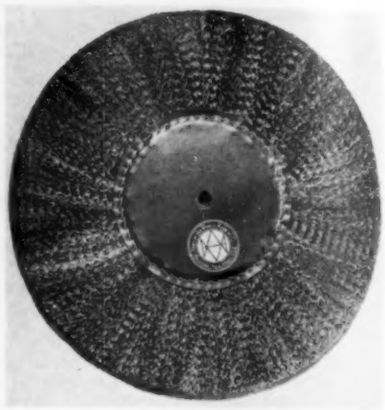
Time, labor and materials would have been required to cast a new rotating field or to build a new shaft, which was approximately 2 feet in diameter and 30 feet high.

Then the suggestion was made that the "chatter" might be eliminated by building up the shaftway with electrodeposition of copper, the largest plating undertaking ever attempted. A deposit varying from two to five thousandths of an inch did the job. The turbine was ready for service in about 24 hours.

Representatives of the Tremont Old Colony Plating Company of Boston plated the shaftway with the assistance of Du Pont's Electroplating Division.

New Wire and Tampico Brushes

The Hanson-Van Winkle-Munning Co., Matawan, N. J., have developed new types of wire brushes and Tampico brushes for cleaning, polishing and finishing metals. Early in the manufacture of these brushes, steel flanges were used, but the steel has now been replaced by fibre, to conserve metal, reducing the shipping weight, and also to place less load on the spindles. The wire



Steel wire wheel section.

sections are made in sizes from 6″ to 15″ diameter inclusive.

The fibre flanges on the Tampico sections make a better brush for the reason that they can be used for either wet or dry work. The sections are made in sizes from 6″ to 18″ diameter inclusive, and the solid brushes, in sizes from 8″ to 18″ in diameter inclusive.

These products have been given the trade name "Staplbond".

"Staplbond" steel wire sections are recommended for cleaning, polishing and heavy

Professional Directory

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SALT SPRAY TESTING — CERTIFIED TO MEET ARMY AND NAVY SPECIFICATIONS. Testing of deposits-thickness, composition, porosity. Solution analyses, plant design, process development.
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All plating solutions analyzed for one dollar each. Reagent solutions for analyzing at reduced prices.
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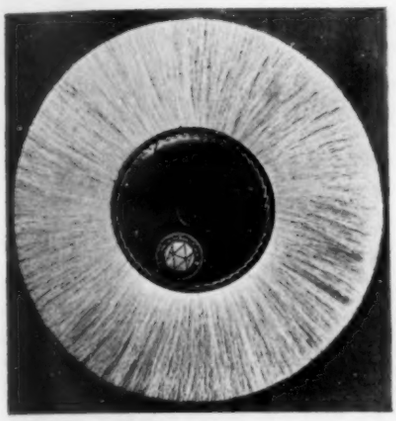
brushing on steel, brass and other metals, rubber, gear teeth and castings, and for removing rust, scale, corrosion, dirt and paint.

The sections feature sturdiness of construction. They are made of specially tempered, high carbon, crimped steel wires, held in place by heavy twisted steel wire welded together, and then placed between high grade fibre flanges which are fastened together with hard tinned steel wire staples, stitched and clinched by an exclusive method, fastening the steel wire securely to the fibre center of the brush.

Each section is compactly filled and the wires stand out stiffly to give a uniformly sharp scratching surface that will wear down evenly without bending or breaking and give a continuous sweeping action not found in other type brushes.



Tampico wheel section.

Each section is approximately ⅜" thick, a complete wheel brush in itself, and is mounted directly on a shaft without the use of a hub or adapters.

Any size arbor hole can be punched out as wanted. Any width of face can be obtained by assembling the desired number of sections on the shaft.

"Staplbond" Tampico sections are used by metal finishers for the polishing and buffing operations. The density of the fibre is suitable for use with compositions and emery paste for producing a variety of finishes.

The sections are made of heavily filled, select, medium grade white tampico fibre, which is evenly distributed in the brush by hand on special machines, and held in place by a triple ring of wire which locks the tampico fibre in a powerful grip.

High grade fibre flanges are fastened together with hard tinned steel wire staples by a special method to hold the tampico fibre securely in the brush. This construction eliminates warping and splitting, and is satisfactory for wet or dry heavy duty work.

Each section has a dense face for efficient performance and is a complete wheel, designed to be mounted directly on a shaft without the use of adapters or hubs. Any desired arbor hole can be punched out as desired. Each section is approximately ½" thick and any number of sections can be assembled directly on the shaft to make the required width of face needed.

A perfectly balanced wheel is obtained by multiple dies which punch the arbor hole and trim the outer periphery of the brush in one operation.

Solid face tampico brushes can be assembled as desired. These are preferred for convenience when the brush is used periodically, as they can be put on and taken off the spindle frequently.

The brushes are assembled of Tampico sections, securely fastened together to produce the required width of wheel from 1" to 6" face.

Manufacturers' Literature

Carbon and Graphite Tubes and Fittings

National Carbon Co., Inc., Carbon Sales Div., Cleveland, Ohio, have just issued their catalog section M-8800A, describing carbon and graphite corrosion resistant pipe, tubes and fittings. Given in the text is a long list of chemicals which either carbon and/or graphite products will withstand. Heat transfer data are given for the company's "Karbate" heat exchangers. Photographs and dimensional data are given on the company's carbon and graphite valves and fittings.

Hard Chromium Plating

A 16 page data bulletin summarizes the applications where industrial chromium plating saves materials and man-hours in the production and maintenance of metal products. The bulletin gives specific examples of how production-rejects and metal-working tools are being salvaged; how the service life of tools, gauges, wearing parts, etc., can be greatly increased; how hard-to-get equipment parts and tools are being reclaimed when worn. Suggestions are also offered on how existing plating equipment can be converted to "hard" chromium plating for war production—or how this work

MICCRO PRODUCTS
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PRESENT-DAY PRODUCTION

These are only a few of the advantages offered by Miccro-Supreme Stop-Off Lacquers and Miccrolite. They are reasons why these protective coatings are meeting the needs of War Production plants in every section of the country.

- Highly effective for the protection of plating racks throughout plating or cleaning cycles and for masking parts for hard chrome plating.
- Valuable in the preparation of parts for selective hardening—eliminating copper plating and removal of plating by grinding after hardening. Keeps grinders free for more productive work.
- Excellent protective qualities when applied on anodizing racks. Provide increased tank capacity and conserve aluminum racks.
- Require only readily available and simplest type of equipment for application. Very little floor area is required.
- Easy to apply and remove. Almost any unskilled plant employee can handle the work.
- Racks coated one day can be used the next morning. No production delays.
- Extremely economical to use.

There are many additional features and applications to specific types of work which can be important to you—in contributing to faster, more efficient production and reducing costs. Completely descriptive literature will be sent you immediately upon request.

Developed and Manufactured By Experienced Platers

MICHIGAN CHROME & CHEMICAL CO.
348 EAST JEFFERSON • DETROIT, MICHIGAN

can be obtained through competent job plating shops. Sent on request for Bulletin No. 56, United Chromium, Inc., 51 East 42nd St., New York, N. Y.

Machine Tools and Machinery

Jefferson Machine Tool Co., Fourth, Cutter and Sweeney Sts., Cincinnati, Ohio, have recently issued an 8-page booklet describing various machine tools made by the company. These tools include milling machines, lathe attachments, swing frame grinding and polishing machines, belt sanding machines and a gyratory foundry riddle. Specifications are given and photographs depict the various machines.

Rust Removal Solution

The International Rustproof Corp., 12509 Plover Ave., Cleveland, Ohio, have developed a solution for removing rust, scale, and burn marks from machine tools, called "Corrosol 26."

According to the manufacturer, this solution does not promote the growth of corrosion after treatment, but instead leaves the metal in a clean, passive condition. It is claimed that the solution does not act upon the metal itself and, therefore, does not dull the cutting edge of tools.

Corrosol 26 is used in a cold solution, and is reported to be harmless to the workman and is non-inflammable.

The company's staff of engineers is willing to go into the fullest detail, either through correspondence or individual inspection of the specific corrosion problems in the trade.

New Books

Treatise on Physical Chemistry. Third Edition. Edited by Hugh S. Taylor and Samuel Glasstone. Published by D. Van Nostrand Co., Inc., 250 4th Ave., New York. Size 9¼" x 6¼"; 672 pages. Price $7.50 ($6.50 each on order for set).

The appearance of Volume 1 of the long awaited revision of the well-known "Treatise on Physical Chemistry" should be welcomed by physical chemists. The former treatise consisted of two volumes, and the present plan is to have it contain five volumes.

Dr. Samuel Glasstone, well known writer and physical chemist, is collaborating with Dr. Hugh S. Taylor in writing the text and working with various contributors.

The progress in physical chemistry has been great in the past twenty years, particularly in the atomic concept of matter. This chapter is written by Dr. Taylor. Chapter 2, entitled "Quantum Theory of Atomic Spectra and Atomic Structure," is written by Dr. Saul Dushman, assistant director, Research Laboratory, General Electric Company. Dr. Taylor contributes the third chapter on "The First and Second Laws of Thermodynamics," and the concluding chapter entitled "The Third Law of Thermodynamics and Statistical Mechanics" was written by Dr. John G. Aston, director of the Cryogenic Laboratory and Professor of Chemistry, Pennsylvania State College, State College, Pa.

Various tables of value in thermodynamic calculations are appended.

The following quotation from the preface indicates the subject matter discussed, and also the tremendous advance in the knowledge of the atomic structure of matter as well as of thermodynamics.

"In the exploration of the atomic constitution of matter, a great mass of detail has been added to the structure as then known (1924). Isotopes, which were then but recently recognized, have now been found in nearly all of the chemical elements, their relative abundances accurately determined and an increasing number separated one from another. With the aid of alpha-particles and laboratory-produced projectiles the transmutation of the elements has been achieved. In addition to the naturally occurring radioactive elements, there are more than three hundred and fifty other radioactive species produced by nuclear transformations. Neutrons and positrons have taken their places beside the proton and electron among the units of atomic architec-

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SMALL PARTS
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THE Bullard-Dunn Process is being used very effectively to clean and descale small parts by means of the barrel shown here. These barrels may be used as individual units as in plating, or they may be attached to the Bullard-Dunn Station Type Conveyor as a full automatic conveyorized barrel unit.
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ture. The quantum theory of energy as developed in the first two decades of the century has been supplemented by the wave theory of matter. Electrons as well as X-rays now serve to elucidate molecular structure and indeed define molecular size and shape. Classical thermodynamics as the basis for the treatment of chemical equilibrium has been amplified by the introduction of statistical methods, ever broadening in range and scope, and permitting even the computation of equilibria inaccessible to experimental test. Applications of these same statistical methods to chemical kinetics have produced also a revolution in this branch of science. The theory of the liquid state and the structure of liquids now merit discussion comparable with that hitherto reserved for the solid and gaseous states. New techniques for study of surfaces and macromolecules, paralleling the brilliant advances of the synthetic organic chemist, are providing the bases for an attack on the problems of complex biochemical systems."

Aircraft Engine and Metal Finishes. By Myron A. Coler. Published by Pitman Publishing Corp., New York. Size 8¼" x 5¼"; 124 pages. Price $1.50.

This book provides a brief description of current American practices employed in finishing the exterior surfaces of aircraft engines and similar parts. It is intended primarily for the reader who is confronted with real problems, but who possesses little or no technical knowledge of finishing procedures; hence, much of the text is devoted to an elementary discussion of the principles on which these procedures are based. Particular attention is paid to organic finishes because of their importance and because of the need for selected, systematic information with special reference to engine-finishing problems.

Chapter headings are as follows: Purposes of Engine Finishing; Nature of Organic Finishes; Preparation of the Metal; Preparing Organic Finishes for Immediate Use; Application Work; Finishing Systems for Engines.

The chapter, "Purposes of Engine Finishing," is particularly good inasmuch as the author uses striking examples from actual practice of the effects of corrosive agents on various metals. Many illustrations are used to augment the descriptive matter in the text.

Although the book is relatively small, it contains a wealth of practical information given in a very easily understood manner, and should be read by all those interested in finishing of metals regardless of whether the metals are for aircraft purposes.

A Simplified System of Organic Identification. By J. L. B. Smith. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y. Size 8¾" x 5¾"; 44 pages. Price $1.50.

This small laboratory manual is an essentially practical work, based upon methods which have proved themselves in the hands of students over many years. The procedure in this system is a departure from the usual method of attack, and by its aid complicating factors are initially eliminated, leaving systematic clear-cut class determina-

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+ CLEANING

This is a war of men against metal. Of machine against machine, and of metal against metal.

Metal cleaning is an important part of all present-day manufacture — whether it is machine guns, airplane parts, cartridge cases (brass and steel), A. P. and H. E. shot, or ammunition boxes. Ammunition and equipment cannot be put into service faster than the component parts can be cleaned.

In these swift-moving times Wyandotte Field Engineers are on call twenty-four hours a day. They are constantly in the field — working with those in charge of metal degreasing in the arsenals and the production shops of the nation.

If you have a problem in metal cleaning, the chances are that a Wyandotte man has met that problem or its twin brother, in the course of his daily work. He will be glad to work with you to obtain improved results, increased speed, or lower costs. *Many times Wyandotte has solved all three problems at once.*

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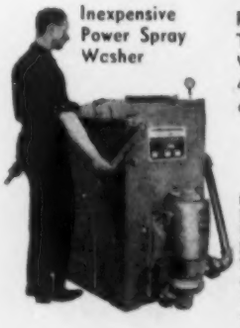
Fast in Action. Efficient and Economical in Service.



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Rotary Table Washer 4 ft. in dia.

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Powerful Motorized Spray Rinse Unit

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tions. The main feature of the work is the presentation of the chief differentiations in the form of tables, which students find easy to follow, so that they rapidly become proficient in this branch of practical chemistry.

Obituary

Frank W. Burman

Frank W. Burman died at sea on July 14 last of a cerebral hemorrhage.

Born in Baltimore, Maryland, March 2, 1898, of Scandinavian parentage, Mr. Burman was educated in the public schools of that city, completing his education with two years of night courses. In 1915, at the age of seventeen, he joined the U. S. Navy and a few years later saw active service in World War I, serving as Chief-Quartermaster and later as Chief Petty Officer aboard the U. S. S. Virginia. Most of his war service was confined to convoy and combat duty in and around the British Isles, where the fighting was thickest. In March, 1919, he joined the U. S. Shipping Board at Washington, D. C., and was again assigned to active sea duty. During his stay with the Merchant Marine, he served aboard various ships in the capacity of Chief Navigation Officer.

In May, 1923, he resigned his position with the Shipping Board to become connected with the Baltimore American, a publication. He remained in the publishing business for four years where he was rapidly promoted, until he became assistant circulation manager. In 1927 he resigned to join with The Egyptian Lacquer Manufacturing Company, where he had remained for the past fifteen years until within a week of his untimely end.

Some time ago Mr. Burman made application to the Navy Department for active sea duty and shortly thereafter he was commissioned a senior lieutenant, with orders to report to Norfolk, Virginia, on July 8th. A few days later, he left aboard a destroyer for his first taste of sea duty in nearly

Lt. Frank W. Burman

twenty years. He was on his way out to sea when stricken. Because his ship was bound for a tour of sea duty it was impossible to turn back and the body was about to be buried at sea in true naval tradition, when an incoming destroyer was sighted and the body was transferred and taken into Norfolk and from there forwarded to Baltimore, where funeral services were held from the home he loved so well on Monday, July 21st.

Associations and Societies

Electrochemical Society

The Fall Convention will be held in Detroit, October 7-10 with the Hotel Statler as headquarters. *Carl E. Heussner* of the Chrysler Corp. is General Chairman but because of Mr. Heussner's illness, *Gustaf Soderberg* is Acting General Chairman. *Charles H. Eldridge* of United Chromium, Inc. is Secretary of the Convention Committee. Electrodeposition will be stressed at the meeting and there will be papers on plating given in a session called "Modern Trends in Electroplating" and there will also be a session on theoretical electrochemistry.

American Electroplaters' Society

Rochester Branch

Annual Picnic

The Rochester branch of the A.E.S. will hold its annual picnic on Sunday, Sept. 13, at the Wishing Well, 1190 Chile Ave., Rochester, N. Y. The picnic will start at 1:00 P.M. and dinner will be served at 6:30 P.M. There will be games, refreshments and good food. A feature will be the baseball game between the Buffalo and Rochester branches.

Reservations can be made with *William C. Treadwell*, 50 Harwick Road, Rochester, N. Y. Tickets: Men, $2.25; ladies, $1.75; children, $0.65.

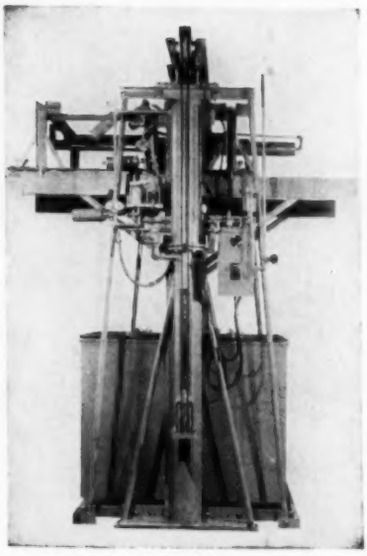
Matchless Metal Polish Co. Elects New Officers

Harold S. Kelshaw, formerly Assistant Secretary, Treasurer and Manager of the Eastern Division of the *Matchless Metal Polish Co.*, Glen Ridge, New Jersey was recently elected Secretary and General Manager of the Matchless Metal Polish Co. and their affiliate, *Advance Polishing Wheels, Inc.*, Chicago, Ill.

W. D. Briggs was elected Treasurer of both companies and *George O'Connell* was elected Assistant Secretary-Treasurer and Assistant Manager in charge of the Western Division of the Matchless Metal Polish Co. and Advance Polishing Wheels, Inc.

W. H. Wagner was elected Assistant Secretary-Treasurer and Assistant Manager of the Eastern Division.

Crown Pick-up Unit



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"Liquid Sulphur"
TRADE MARK REG'D

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EMULSION TYPE
SOLVENT CLEANER

★ Removes oil, grease, smut, grime, drawing and buffing compounds on all metals. LIXOL produces no chemical attack on sensitive metals. Protects metal against rust and tarnish, leaves surfaces ready for painting. Small parts are dipped in LIXOL at room temperature and rinsed with either cold pressure rinse or hot still rinse. LIXOL can be sprayed or brushed on large parts, rinsed with pressure spray. Adaptable to simple equipment. No fumes or objectionable odor and harmless to hands. Immediate delivery. Send for suggestions for application of LIXOL to your particular problem.

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USED IN MANY PLANTS FOR DEGREASING

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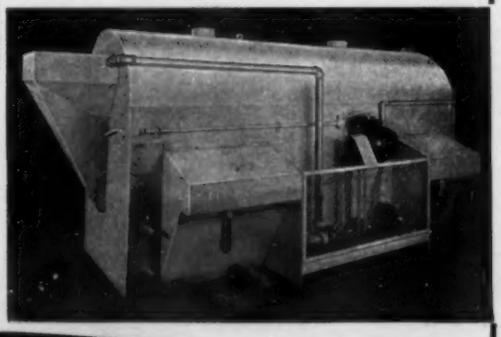

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Township and Big 4 R.R. CINCINNATI, OHIO
Cleaning Machinery Specialists

Metal Cleaning
EQUIPMENT

Personals

Arthur W. Logozzo with Hartford Chromium Corp.

Arthur W. Logozzo, formerly in charge of chromium plating at the Pittsfield Works of the General Electric Co., has joined the *Hartford Chromium Corp.*, 525 Park St., Hartford, Conn., and will serve as shop superintendent. Mr. Logozzo has been very active in the American Electroplaters' Society and has published numerous papers on the subject of hard chromium plating of plastic molds. His latest paper was presented at the annual convention of the American Electroplaters' Society, held June 8-10 of this year at Grand Rapids, Mich. He was awarded First Certificate for plating exhibit at the annual A.E.S. convention held in Boston, June 9-12, 1941.

Dr. F. R. Holden Joins Staff of Industrial Hygiene Foundation

The appointment is announced of *Francis R. Holden, Ph.D.*, a specialist in healthful working conditions, as industrial hygienist on the staff of *Industrial Hygiene Foundation* at Mellon Institute, Pittsburgh. He will assist companies associated with the Foundation in controlling employee health hazards which are increasing with peak war production.

Dr. Holden, basically a physical and organic chemist, took his undergraduate work at Hobart College. He has specialized in industrial hygiene since completing his graduate studies at the University of Cincinnati in 1934.

After a year at the Industrial Health Conservancy Laboratories in Detroit, working on hygienic problems in the automobile industry, he joined the Safety Department of the Pittsburgh Plate Glass Company where he was engaged in industrial hygiene for more than 5 years. For the past year and one-half Dr. Holden has been on the natural gas fellowship at Mellon Institute.

Dr. Holden will be in charge of industrial hygiene surveys of all types for Industrial Hygiene Foundation. Industrial health problems in manufacturing are growing with the increased use of chemicals, longer hours of work, intense war efforts, and the employment of women workers and older men.

M. A. Thompson, who has been in the Heavy Chemical Sales Division of the *Pennsylvania Salt Manufacturing Company* in the Detroit area since March, 1938, has been transferred to the Industrial Cleaner Division. He started with the company in 1934, spending his first four years in various plants. Although assigned to the Heavy Chemical Division, he has assisted in the sale of Pennsalt Cleaners and is well known in that field.

Harry M. Ellsworth, advertising manager of *Pennsylvania Salt Manufacturing Company*, chemicals, has been elected vice-president of the Eastern Industrial Advertisers Association for the 1942-43 term.

The association membership is in the Philadelphia, Chester, Wilmington and Trenton areas. Mr. Ellsworth also serves as chairman of the employment section for the Eastern district of the National Industrial Advertisers Association.

The Hanson-Van Winkle-Munning Co., Matawan, N. J., announce the appointment of *Benjamin F. Parlett, Jr.*, to the sales force of the company. Mr. Parlett has had wide industrial experience, principally in the steel industry, and has a host of friends in the Pittsburgh district.

He has been associated for the past several months with *Glenn M. Herring* who for many years has represented the company in that territory. Mr. Herring is now on duty with the Army as an officer in the Air Corps.

Robinson D. Bullard, reclamation engineer for the *Bullard Co.*, makers of Mult-Au-Matic and Vertical Turret Lathes at Bridgeport, Conn., has been appointed technical consultant to the Industrial Salvage Section of the Bureau of Industrial Conservation of the War Production Board. He will assist in preparing a definitive book on industrial reclamation.

J. M. Boudreau, formerly secretary and treasurer of *Du Puis Process, Inc.*, has become general manager of *Eastern Metallizing Co.*, 422 E. 110th St, New York. This company is engaged in metallizing as well as technical service pertaining to metallizing.

Business Items

Research on Nickel at Mellon Institute

The International Nickel Company, Inc., New York, N. Y., has resumed investigational work at Mellon Institute of Industrial Research, Pittsburgh, Pa., by the establishment of an Industrial Fellowship that began operation on July 1. This Fellowship is concerned with a comprehensive program of scientific research on certain problems

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For plating brass, bronze, cadmium, chromium, copper, gold, lead, nickel, silver, tin and zinc.

LEAD PLATING

The use of lead plating is steadily expanding—have you considered it for your products? Harshaw Lead Fluoborate, diluted with water provides a simple, economical and efficient plating bath.

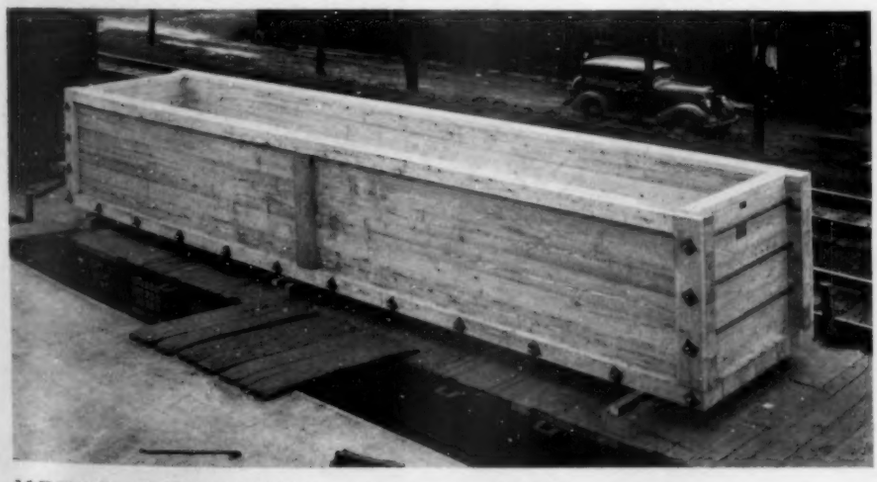
SILVER PLATING

Use Harshaw Silver Cyanide and Silver Chloride for pure, dependable silver solutions.

ANODIZING

Harshaw Chromic Acid is guaranteed to meet all government and commercial specifications. . . . Immediate shipment from stock points.

THE HARSHAW CHEMICAL CO.
Cleveland, Ohio and Principal Cities



We can give excellent service on all types of

WOOD TANKS

The shortage of metals has increased the demand for wood tanks for plating and pickling service. We can give excellent service on all types of tanks. Send us your inquiries.

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KALAMAZOO TANK & SILO CO.
KALAMAZOO, MICHIGAN

Cutting Corners
. . . . for Top Speed Production
Rounding corners or removing burrs by grinding or filing is too slow and costly to meet today's demands for speed and economy.
Barrel finishing has solved many such problems. Write to us about yours and send a few unfinished samples of your small, metal parts. We'll gladly tell you if they're adapted to finishing with Abbott barrels and materials.
The Abbott Ball Company
1046 New Britain Ave. Hartford, Conn.

In the development of better practices for accelerated production in War work

BLACK-MAGIC

"the one-bath process"

will be found an invaluable aid in finishing all steel fabrications requiring a rust inhibiting black surface.

BLACK-MAGIC processes for steel, iron, bronze, brass and zinc are *Government approved* and are used on millions of parts daily.

WITCH-DIP a wax base final dip is a substantial rust-proofing.

If you have a blacking or a rust-proofing job let us hear from you.

Write for free portfolio of complete information.

THE MITCHELL-BRADFORD CHEMICAL CO.

BRIDGEPORT, CONN.

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A. J. Walch, 35 E. Wacker Drive, Chicago, Ill.
Lea Manufacturing Co., Waterbury, Conn.
Wm. H. Price, Jr. (Divisional Mgr.), 2908 Rising Sun Rd., Ardmore, Pa.

UNPARALLELED UNIFORMITY

AS WITH HARRISON'S 4A PRODUCTS

FOR GETTING MORE WORK FROM YOUR GRAIN USE

4A CEMENT and THINNER

A Substitute For Glue

NO WORRY ABOUT GLUE SHORTAGE WITH 4A CEMENT AND THINNER. Polishing wheels are free cutting, long lasting and economical when set up with 4A Cement.

COLORING ROUGES UNIFORM, CAREFULLY GRADED RAW MATERIALS, EXPERTLY COMPOUNDED BY HARRISON'S TECHNICIANS, INSURE ROUGES THAT GIVE HIGH LUSTER AND FAULTLESS FINISHES.

POLISHING COMPOUNDS 4A symbolizes these four features which you require for high speed polishing, mirror finishing of all kinds of steel, including stainless steel, carbon steels and hard-to-buff alloys. Use it on any kind of a wheel, soft, medium or hard.

Tell us your problem and samples of compounds, rouges or cement will be sent.

We will be pleased to recommend proper methods.

"AMPLE STOCKS TO TAKE CARE OF OUR TRADE"

4A **HARRISON and COMPANY**

Haverhill, Mass.

in the chemistry and technology of nickel, embracing particular attention to the preparation, properties, and uses of nickel compounds, especially organic derivatives.

Dr. John Gilbert Dean, a physico-organic chemist, is the incumbent of this Fellowship. He received his professional education at Brown University (Ph.B., 1931; M.S., 1932) and Columbia University (Ph. D., 1936) and has subsequently had five years of experience in applied chemical research.

Benwood Linze Company Takes Over the Fore Electric Company

The Benwood Linze Co., St. Louis, Mo., designers, engineers and manufacturers of electrical rectifiers and rectifier-transformer assemblies announce a further step in their overall program of expansion, namely, the purchase of the *Fore Electric Co.*, located at 4800 Delmar Blvd., St. Louis, Mo. The purchase includes all of the company's equipment, inventory, assets and trade name. All facilities have been moved to the plant of the Benwood Linze Co., at 1815 Locust Street.

The Fore Electric Co. was founded in 1917 under the direction of Albert Wehmeier, a well known figure in the automotive and electrical industry for many years and who today is the retiring president of the firm.

The company manufactured battery chargers of both vibrator and bulb type, magnetizers, transformers and electrical meters. All products were manufactured under the trade name, "Fore."

The Benwood Linze Co. will continue to manufacture and distribute the products of the Fore Electric Co., including replacement parts for same.

The purchase of the Fore Electric Co. substantially augments the corporate structure of the Benwood Linze Co. and its wholly owned subsidiary, the B-L Electric Manufacturing Co.

California News

By Fred A. Herr

Manuel Sanz, process engineer of the Vultee Aircraft Co., Downey, Calif., will be the guest of honor at the September meeting of Los Angeles Branch, A.E.S., in recognition of the distinction brought to the branch by winning first prize at the national A.E.S. convention in Grand Rapids, Mich., for the best paper published in the *Monthly Review*.

Mr. Sanz' prize winning paper, "Chromic Acid Baths for Anodizing or Chromatizing Aluminum or its Alloys," was read at the June 11, 1941, meeting of Los Angeles Branch and subsequently appeared, complete with photograph and graph illustrations, in the October, 1941, issue of METAL FINISHING.

Members Los Angeles Branch, A.E.S., helped *Emmette R. Holman*, president of the branch, and Mrs. Holman properly "launch" their new home in Pasadena, Calif., with an old-fashioned housewarming on Sunday July 19.

DO YOU HAVE A PROBLEM OF DEBURRING OR GRINDING AND POLISHING PRECISION PARTS?

Regardless of size or shape, Lupomatic has a way of handling your particular job. We are equipped with a Laboratory to work out your problem free of charge. We place our Engineering Dept. at your service.

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BRASS SHEET

Bronze and Gilding

Processed For Difficult Drawing Bright Finishes

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HIGHEST STRENGTH
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POSSIBLE TO PRODUCE

Sold in LUMP and LIQUID FORMS
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Manufactured For 66 Years By

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PLATERS and POLISHERS DATA BOOK

Chemical Engineering Data, Useful Tables, Instructions. How to clean Easier, Quicker, Less operations, No peeled plate, no rejects.

Send for FREE copy today

Puritan Mfg. Co., Waterbury, Conn.

Originators and Manufacturers of
WONDERBAR, *Pre-Saponified*
BUFFING, POLISHING COMPOUND

The new Holman residence, situated at the foot of the mountains which rim the city, was an ideal setting for an al fresco dinner which was served in the park-like backyard.

The Holmans were presented with a gift in the form of an electric clock, on the base of which were engraved the names of the donors. Present were *Mr.* and *Mrs. Clarence E. Thornton, Mr.* and *Mrs. E. W. Francis, Mr.* and *Mrs. Carroll McLaren, Mr.* and *Mrs. Earl Coffin, Mr.* and *Mrs. Stanley Rynkofs, Mr.* and *Mrs. James ApRoberts, Mr.* and *Mrs. Don Bedwell* and daughter *Lorraine, Ernest Lamoureux and Marcus Rynkofs.*

James ApRoberts has resigned as analytical research chemist in the Turco Products Co.'s Los Angeles laboratory and on July 13 took up duties in the Navy's Paint and Chemical Division at Vernon, Calif. *Keith Brown* has succeeded ApRoberts on the Turco staff. Another addition to the Turco laboratory personnel is *Miss Jean Wynkoop.*

Fred Emmons and *F. R. Kinkle* have established the Aero-Plating Co. at 3970 East Olympic Blvd., Los Angeles.

Other recently opened new plants with metal finishing and treating departments are:

Fletcher Aircraft, 625 West San Fernando Road, Burbank, Calif.

Transco Parts Supply Co., Inc., Los Angeles.

Shaw Machine & Tool Co., 1151 Temple St., Los Angeles.

Boardman Precision Mfg. Co., 2014 West Commonwealth Ave., Alhambra.

Sklar Steel Products Co., San Francisco.

Engel Aircraft Specialties, Delmar Highway and 9th Ave., Escondido, Calif.

H. L. H. Precision Parts, Inc., Hollywood, Calif.

VULCAN SODIUM STANNATE

Manufactured by

THE VULCAN DETINNING CO.
SEWAREN, N. J.

Under Patents Nos. 1,575,217 and 1,708,392

FOR TIN ELECTROPLATING

SALES AGENT

The R. & H. Chemicals Dep't, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

HECCO BRAND EMERY

Made from the highest quality selected ores obtainable in this country and in the same careful and thorough manner as imported emeries.

These rough-surfaced solid-shaped grains hold unusually well in the glue.

Write for full details.

HAMILTON
EMERY & CORUNDUM CO.
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CHROMIUM PLATING
SCREWS—RIVETS—WASHERS
SMALL PARTS, ETC.

THE CHROMIUM PROCESS CO.
Shelton, Conn.

BUFFS, CLEANERS

Buffing Compositions
Nickel Anodes
Chemicals and General Supplies

JACOB HAY COMPANY
4014 W. Parker Avenue
Chicago, Ill.
Albany 2742

RIBBON ZINC
For stamping and drawing

FUSE METAL
For fuse elements

ZINC WIRE

The Platt Bros. & Co.,
Waterbury, Conn.

Truly—Three Great Finishes!!

CHROMIUM—UDYLITE—SHERARDIZING

For over a quarter of a century building and installing portable sherardizing furnaces and equipment; metal finishing and plating. We invite your inquiry.

THE NATIONAL SHERARDIZING & MACHINE CO.

Office & Factory Hartford, Conn.
Foreign Representatives—Oliver Bros., Inc., 417 Canal St., N. Y. City

Today's Efficient Method of Volume Finishing

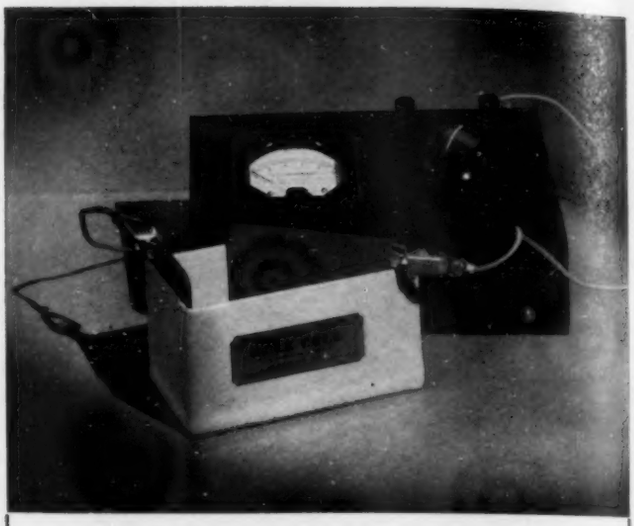
•AUTOMATICALLY POLISHING & BUFFING

Increase Production—Lower Costs—More uniform finish on articles of varied sizes and shapes. Controlled finish from one operating station.

•AUTOMATIC POLISHING & BUFFING MACHINES

Packer-Matic

THE PACKER MACHINE CO., MERIDEN, CONN., U. S. A.



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New small size now available for controlling and developing plating solutions.

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★ TESTING SETS FOR ALL SOLUTIONS ★

ROBERTS BUFFING COMPOUNDS ASSURE

The Best Quality, Correct and Uniformly controlled manufacturing, Fair Price Policy, and Special Formulas for Individual Demands.

WE PRODUCE

ROUGES (Iron Oxides) (Quick wash)	All types
TRIPOLI	Numerous grades
EMERY PASTE	All size grains
COMPOUNDS	For every metal
GREASE STICKS	For better efficiency
LIME COMPOUNDS	Many formulas

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NICKEL SILVER

Sheets—Rolls

Phosphor Bronze, Bronze Gilding Metal
Low Brass and Special Alloys

WATERBURY ROLLING MILLS, Inc.

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PERMAG

SOLUTIONS Guarantee a Clean Surface for—

Chemical Blackening of Metals

Black finishes are frequently required by manufacturers engaged in production of metal products for Army, Navy and other warfare departments.

This finish is applied to Iron, Steel, Aluminum, Aluminum Alloys, Copper, Brass, Bronze, Zinc and Zinc Alloys.

PERMAG Solutions are used with greatest satisfaction to obtain an absolutely clean surface for a perfect finishing job—thus eliminating rejects and increasing production.

If you experience any difficulty with black finishes, let us help you. Write at once. No obligation for interviews.

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